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TECHNIQUE EMPLOYED IN GRASSLAND RESEARCH IN NEW ZEALAND.

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IMPERIAL BUREAU OF PLANT GENETICS : HERBAGE PLANTS

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TECHNIQUE EMPLOYED IN GRASSLAND RESEARCH IN NEW ZEALAND.

[FOREWORD BY A. H. COCKAYNE, AND CONTRIBUTIONS
BY E. BRUCE LEVY, J. W. HADFIELD, A. W. HUDSON,
J. W. CALDER, W. A. JACQUES, B. W. DOAK AND N. R. FOY.]



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INTRODUCTORY NOTE.

This Bureau has been collecting during the past months contributions from research stations in Great Britain and certain Dominions on the question of technique in pasture and grassland research, with a view to publishing them finally in Bulletin form. It has been considered advisable to publish the New Zealand contributions separately, as the amount of material available and the fact that this material represented a compact unit referring especially to New Zealand research seemed to warrant such a procedure.

It will be understood, therefore, that the various papers included in this Bulletin are to be considered in conjunction with those to be presented in a later publication dealing with aspects of the same problems in other parts of the Empire.

R. O. WHYTE.

Names of Corresponding Editors and details of Herbage Publication Series at end of Bulletin.

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TECHNIQUE EMPLOYED IN GRASSLAND RESEARCH IN NEW ZEALAND.

FOREWORD.

A. H. COCKAYNE.

Director, Plant Research Station, Department of Agriculture.

Apart from the comparatively small domestic agricultural production to provide for a population of one and a half million of people, almost the whole of New Zealand farming is concerned with the production of animal products, and over 95 per cent of the export trade of New Zealand consists of meat, wool and butterfat, which is produced almost entirely from grass.

Grass farming is still in an active evolutionary stage and the essential requirement in New Zealand is the controlled development of this art in harmony with the peculiar local conditions. Until comparatively recently, progress in grassland farming was viewed as comparatively unimportant and would be best served by the adoption of more intensive methods of general farming based on European standards rather than on specific attention to grassland production and maintenance based broadly on the evolutionary history of the art as it has been developed in New Zealand. The multiplicity of ecological factors in relation to grassland farming have been under intimate study in New Zealand for at least two decades, and this ecological approach that has been developed by the Department of Agriculture has led to a deep grass-mindedness and realization of the great importance of grassland farming as an art.

On this groundwork of ecological study rests the basis of our research work of the present time. The ecological knowledge of the behaviour of species and the relative successes and failures accruing on the sowing-down of standard species on standard habitats led to the importance of strains of pasture species and the need for promulgation of approved ecotypes under a system of seed certification.

The influence of the grazing animal and the ecological concept of the biotic factor in general, together with our knowledge of the competitive forces within grassland associations, has led to better methods of utilization and has set standards based on manurial requirements of association types. Out of this has come the demand for a technique that will record production without violation of the general ecological principles underlying the grazing by stock. The alternate mowing and grazing technique has been developed by Hudson.

The need of the art to know the economy of seed mixtures and in general to record the rise and fall of species on application of specific practices, such as manuring, rotational grazing, close and continuous grazing, etc., called for a technique that would measure accurately such change in pasture composition. The New Zealand point method of pasture analysis was evolved to meet this demand.

The ecological conditions of the habitat and later the plant selector and breeder have modified existing species that are basic to grassland and the identification of plant species or type based on the systematics of the group failed when such species or type is viewed from an agronomic standpoint. The physicist and chemist have been employed and the ultra-violet light lamp and the chemist's retort are opening up new diagnostic means of identifying plant types.

The call for research is from the art and the results of research to be effective must be translated back to the art in the language of the artisan. This has called into being the New Zealand system of field demonstration trial and a technique in organization that provides a vehicle for free intercourse between the district organizer, the research worker, and the farmer.

The following papers by the main workers engaged in New Zealand in grassland investigation indicate on broad lines the various methods of approach that are being adopted. They should be considered more in the light of the requirements of the art rather than as contributions of an academic nature that may have little or no application to the art itself.

1.—STRAIN TESTING AND STRAIN BUILDING.

E. BRUCE LEVY.

Agrostologist, Plant Research Station, Department of Agriculture.

This work in New Zealand is developing along the following set plan: (1) Collection of material, (2) Testing of material by broadcast plot trial and single plants, (3) Isolation from material of ecotypes of outstanding merit, (4) Location and introduction into commerce of these ecotypes under certification, (5) Single plant study of approved ecotypes, (6) Selection of the most promising single plant material, (7) Study of these over a three-year period including selfing and crossing of parental material in cages, (8) Increase of approved parental material under isolation within glasshouses, (9) Increase of glasshouse progeny on Pure Seed Station under good field isolation conditions, (10) Increase of Pure Seed Station progeny on the farmer's fields under certification, (11) Progeny testing of mother seed and its farm-grown progeny to study critically trueness to or deviations from type by outgrowing.

PHASE I.

(1) *Collection of material:*

The commercial seed sample has been the basis of material studied to date. It is assumed that such samples, if sufficient are tested from all sources, will cover the entire range of habitats where pastures abound and thus will be representative of natural ecotypes where these have been evolved as a result of the biotic, edaphic and climatic factors governing the habitat. It is reasonable to surmise that where an ecotype has been developed to the point of assuming dominance in old established grassland, such areas would yield payable seed crops which would sooner or later come to be harvested and appear as commercial entities. The commercial seed sample is practically the only way in which strains of outside countries may be secured, and I feel that unless strains from grassland habitats other than one's own country or district are tested, years of work may be necessary to build up a strain to a point already reached by a natural ecotype in some other part of the world. Habitat selection of plants in the South Island of New Zealand, for example, would not have led to the discovery of the Hawke's Bay strain of *Lolium perenne*. Habitat selection anywhere in New Zealand would not have produced the Montgomery red clover strain, and years of work would have been necessary on the broad red group to have raised a strain as persistent as this ecotype. Again one feels years of work in Great Britain or in Europe would be necessary to evolve a type of *Trifolium repens* as productive and as persistent as the N.Z. No. 1 white clover, or the N.Z. type 1 perennial ryegrass. The same may be said of Akaroa cocksfoot. These ecotypes may represent years of gradual progress by habitat selection alone. Hence a critical examination of world trade lines would soon show any one worker whether material superior to that of his own country was available for his work of pasture improvement by strain building.

The samples tested at the New Zealand Plant Research Station have been secured direct from seed merchants, from plant breeding stations, and through the New Zealand official seed-testing station after germination and purity reports have been issued. In connection with certification of ryegrass alone, this year some 1,500 samples are available for trial representing an aggregate area of 23,000 acres, every paddock of which may be traced if necessary. Seed certification is a boon to research since the authenticity of origin of one's material is guaranteed. The seed merchant also is one of our greatest allies.

The first step therefore in our strain testing was to analyse the commercial trade lines of the world and place them according to performance into definite groups. Thus to date the *Lolium perenne* lots fall into six major groups; the *Trifolium repens* into five; *Dactylis glomerata* into three; and *Trifolium pratense* into four major groups respectively.

The next step was to trace these major types back to district of origin and habitat. Thus in a comparatively short time (3 years) valuable ecotypes existing in exploitable quantities were located, and these are now being propagated and multiplied under certification.

(2) *Testing of material by broadcast plot trials and single plants.*

The seed samples are first given a station number and are entered in the station register with such details as date received, date of letter of advice, firm or farmer sending in sample, the firm's distinguishing mark, name of grower and district of origin, amount of seed sent, germination and purity, and, when available, the percentage fluorescent seedlings in the case of ryegrass and the percentage of HCN in the case of white clover. Next come date sown and location of trials, together with amount of seed remaining on hand. A system of abbreviations has been adopted following the lead of the Welsh Plant Breeding Station in this respect. Where sufficient seed is available, broadcast sowings are made, otherwise sowings are made in rows. Sowing in rows is also adopted in the case of white clover lots in order to eliminate contamination due to volunteer white clover seed that is lying dormant in the soil. In the case of white clover two rows 2 feet apart are sown with the same line, and these two rows are kept intercultivated until such time as they join up by lateral spread to make a broadcast plot 4 feet wide (Fig. 1). By this system the chances of contamination by self-sown volunteer white clover are reduced to a minimum. In the early days of the trials when developing this technique one row of each lot was sown in sterilized soil, but as no apparent differences were noticeable as far as purity of the stand was concerned between the row sown in sterilized soil and that in ordinary soil the use of sterilized soil was abandoned. The standard plot now adopted for almost all strain-testing trials is $6\frac{3}{4}$ links wide by 15 links long = $1/1000$ acre in area. In the initial trials a triple system of utilization was practised ($\frac{1}{3}$ cut continuously with lawn mower, $\frac{1}{3}$ cut at ensilage stage, and $\frac{1}{3}$ cut as hay) until such time as performances of the major types were correlated with definite eye appearances. To-day, in testing unknown samples of the major species this triple system is not necessary because one soon comes to determine by eye whether a line is worth additional study. Control plots of known types are always used at regular intervals throughout the area where unknown lots are being tested. Sowings are made broadcast by hand, binder twine being used to denote plot boundaries for sowing out. The following are some of the rates per acre of seeding: *Lolium perenne*, *L. italicum*, 40 lb.; *Dactylis glomerata* 30 lb.; *Phleum pratense*, 20 lb.; *Agrostis* spp., 20 lb.; Chewing's fescue (*Festuca rubra*), 30 lb.; *Trifolium pratense*, 20 lb.; *T. repens* sown in drills 1 gram per single drill of 15 links.

These broadcast plots are kept under close observation from the time they come through the ground, and records are compiled by a series of notes. A scale of 0-10 is used for major differences such as speed of establishment, tillering and spread; relative growth, density of sward; recovery after cutting, persistency, rate and extent of flowering; disease susceptibility, etc. Field notes are made in surveyor note-books that are ruled off roughly into columns. Each field book is numbered. From the field note-books permanent records are made in the office register on cards, one card to each sample. This work of transferring field notes to the permanent card records is done by the clerical service and it relieves the specialist officer from an enormous amount of time and tedious work.

In this preliminary work of strain testing no regular weighings are attempted. The work is done entirely by eye and in this way many hundreds of lines can be examined in one day. After 12 months down—less in some species—a very good idea can be formed of the relative merits of the lines, and after this period lots may be selected for critical study as single plants. All plots are manured, and a relatively high soil fertility standard is maintained. This is particularly desirable where work is designed to benefit high-, or potentially high-producing soil types. Species, strain, fertility, management are basic concepts in grassland farming and all should be taken into account before relative values of strains can be assessed.

3.—*Isolation from material of ecotypes that are of outstanding merit.*

Having secured seed samples from the most important grassland countries and habitats within those countries, and having tested these out as broadcast plots and as single plants,

the isolation of ecotypes from this mass of material is a relatively simple matter. For New Zealand conditions at least, we have tentatively adopted the following ecotypes as being worthy of exploitation: (1) Hawke's Bay and Poverty Bay perennial ryegrass, (2) Akaroa cocksfoot, (3) New Zealand No. 1 white clover, (4) Extra Late red clover of the Montgomery red clover type, (5) Kentish wild white clover, (6) Marlborough lucerne, and (7) New Zealand brown-top (*Agrostis tenuis*) for lawns.

It happens the majority of these are New Zealand products; this is not surprising when one considers the vast potentialities for development of European species under the inimitable grass-land climate of New Zealand. Nevertheless, workers in New Zealand would welcome samples of any of the above or other grassland species that when tried out against the above ecotypes prove superior to them in production and persistency. In this way may yet be found elsewhere some ecotype superior to our own to our lasting advantage. Samples of the New Zealand ecotypes will on application be sent to any worker interested.

4. *Location and introduction into commerce of approved ecotypes under certification:*

By sample trial of individual farmer's lines, received direct from the farmer or through the seed-merchant handling his seed, ecotypes are gradually located. The mapping of farms under certification enables samples so secured to be traced back to the individual paddocks of the farm. Seed certification [see paper 2], is the culminating phase of strain building, and to my mind is essential for the safe commercialization and security of improved strains. Selection and breeding and the increase growing of bred lots under isolation demands meticulous care. All this work is valueless without adequate machinery to launch and safeguard that seed in the open markets of the world.

PHASE 2.

PROGRESS TOWARDS ÉLITE OR PEDIGREE HERBAGE SEEDS TO REPLACE UNSELECTED NATURAL ECOTYPES.

5. *Single plant study of approved ecotypes:*

Bulk seed of all plot-tested lines is kept in reserve in ratproof galvanized iron bins and a small representative sample is filed away under its station number in a cabinet in the working laboratory. Seeds of those lines which have proved under plot trial worthy of further critical study are sown thinly in boxes in sterilized soil, and when large enough to handle are pricked out as spaced plants in boxes in sterilized soil approximately 2 inches apart each way. Sowing with later pricking out is found to be better than sowing spaced individual seeds, particularly when dealing with lines of low germinating capacity. These plants when well rooted and before they become crowded in the boxes are put out 2 feet apart each way in rows of 10 plants, this number per row being found the most suitable for subsequent note taking. (Figs. 2 and 3.)

6. *Selection of the most promising single plant material:*

From 4,000-5,000 single plants thus arranged, a very good idea can be obtained as to the relative value of any one particular line or number of lines of the same ecotype, and in general it has been found that from this number of single plants sufficient elite single plant material after a 2- to 3-year trial can be selected. The best of these single plants are now lifted—4,000-5,000 single plants may give 150 super-type plants, and each plant is split up into tillers and planted out as a tiller row and tiller single plants. The tiller rows at the station are 20 lks. long; there are six tiller single plants spaced 2 ft. apart each way. In this way habitat variations may be checked and minor differences in growth form, recovery after cutting, disease susceptibility, etc., are clearly discernible.

7. *Study of these elite single plants including selfing and crossing of parental material in cages:*

These 150 super-type plants may be under test as tiller row and tiller single plants for a further 1-2 years, by the end of which time some indication will have been given as to what constitutes really superior plants. The more promising types of the 150 single plant lots may now be genetically examined, but this stage is but in its infancy in New Zealand. For selfing,

cellophane bags under glass are employed, and for mutual cross-pollination in pairs specially constructed glass cages $24 \times 18 \times 27$ inches high are used. For grasses these consist of cages open at the bottom, with glass sides and top. Ventilation is provided by a specially constructed vent, one on each side and placed near the top. This vent is guarded by two sheets of fine copper gauze, one inside the cage and one outside, between which a packing of cotton wool is used. The double gauze itself is fairly effective as this provides a dead air chamber between, but one feels the packing of cotton wool gives added security. It must be said that these cages are quite experimental; subsequent work may show that added precautions are necessary to make the vent 100 per cent pollen-proof. A wire shaker is inserted in one side. Plants grow extremely well in such a cage. For clover a similar sized cage is used, but there the sides are of $\frac{1}{8}$ in. mesh iron gauze, the top being of glass, while one side is provided with a door to facilitate insertion of the bumble bees. All plants for selfing or crossing are potted for ease of handling, but cages may be placed for selfing over single plants or part of single-plant tiller row in situ.

The small bumble bee (*Bombus hortorum*) has been found most suitable for clover pollination work.

8. *Increase of approved parental material under isolation, preferably in glasshouses:*

At the present time glasshouses are in course of erection at Palmerston North for this purpose, and the technique of the Welsh Plant Breeding Station—Bulletin No. 3 of this Bureau—will be followed. Up to the present, increase of selected single plants after three years' trial has been made as follows. Ten of the best plants have been chosen and split up into tiller or single plant rows, an area sufficiently large being planted to give enough seed to sow out at least $\frac{1}{2}$ -acre on the Pure Seed Station as outlined below.

In the selection of these ten best plants, if all ten are equally good and have individually given good progeny, exact similarity of type is not stressed, the assumption being that a mixture of good types representing earliness, midseason and late seasonal growth is more to be desired than a pure line that may start growth early in midsummer, or late. A pure line will tend to show a sharp production peak, whereas a mixture of good early, mid and late types will tend to broaden that peak and thus ensure for that species a longer total season of growth resulting in a more uniform spread of production throughout the growing season. This is an extremely important point in assembling our mixture of strains. The more perfect state, of course, would be a separate mixture of strains in much the same way as a mixture of species; but the machinery for keeping true to label a number of pure line types of, say, ryegrass, cocksfoot, red clover, white clover, etc., would be extremely cumbersome. For this reason the work in New Zealand will be based on a mixture of good types within the élite strain rather than on a number of separate strains.

9. *Increase of glasshouse progeny on Station field area under as good field isolation conditions as possible:*

This work is transferred from Palmerston North to the Pure Seed Station situated in the heart of an ideal seed-production area at Lincoln in Canterbury.

10. *Increase of Pure Seed Station product on farmer's field under certification:*

The aim here is to sow out on the farmer's field a minimum area of five acres. This will be sown in the ordinary way and the crop harvested through the ordinary channels of seed certification.

11. *Plot testing of mother seed and farm grown progeny:*

This is a vital feature of the general certification work and applies to all classes of certified seed. Representative lines of mother seed are sown out alongside the once-grown progeny from that seed and the results of once-growing noted. These lots are also put out as single plants, and by this means any deterioration of type may be better observed. Obviously every line of certified seed cannot be tested in this way, but these trials provide sufficient check on type to ensure that the general level of certified seed is kept up to a predetermined standard.

GENERAL ROUTINE TECHNIQUE.

Methods of defoliation :

Mowing with a lawn-mower, cutting with a scythe, and grazing with sheep are all employed for defoliating the crop, broadcast plots, tiller rows, and single plants. For a large number of plots and single plants, sheep are by far the cheaper to employ, and perhaps greater reliance can be placed on defoliation by stock rather than by mowing continuously or by scything. The grazing area of the station consists of 6 acres of ground. This area is divided up into 65 link-wide sections that provide for 20 single plants wide (2 lots back to back) or 4 broadcast plots deep and a 5-link path that is laid down permanently in a lawn mixture of brown-top and Chew-ing's fescue. These 65 link-wide sections are fenced lengthwise with a light wire netting fence, and hurdles are used to pen the sheep on to the whole or part of these sections. To graze these fenced sections which are each $\frac{2}{5}$ acre in area 12 sheep are used. It is our experience that this small number of sheep do practically no damage to the plot labels which are consequently not removed during the grazing. Where the feed has become long each section is fed off in breaks by means of the hurdles so as to clean up a portion at a time. A certain amount of trimming up after stock is required, particularly in the single plants, when these run to head before being grazed. White clover single plants are trimmed back to the crown by means of a sharp spade.

RECORDING OF OBSERVED DATA.

The 0-10 system :

Data relative to broadcast plots, tiller row, and single plants are recorded in the main by the 0-10 system of marking. This system, which was introduced here by Mr. William Davies, of the Welsh Plant Breeding Station, during his two years' sojourn in New Zealand,* may be employed for an indefinite number of observations and can be used where other methods would be quite impossible. For example, relative speed of establishment, relative early recovery after cutting, relative susceptibility to disease, etc., are difficult to record by specific measurement methods, and the time necessary for such measurements is quite out of proportion to the extra advantages gained.

Cutting and weighing.

This method has been employed to a small extent only. Cutting and weighing, to be of much value, demand botanical analyses and dry weight determinations of the cut herbage before comparative figures are reliable. These analyses require a comparatively large technical staff, and the number of individual plants or plots that can be handled is small when compared with the 0-10 system. In the ultimate analysis, however, where differences are small, cutting and weighing (see paper 3) may be necessary.

Point quadrat method of pasture analysis :

This method is based on the mathematical concept of the homogeneity of a unit area as represented by a pin point. Provided a sufficient number of pin points are taken an elaborate picture may be reproduced. The photographer's half-tone reproduction is a case in point. In charting vegetation, provided a sufficient number of pin points of vegetation are examined, an accurate representation of that vegetation will be secured. The method had its origin in a suggestion made to the writer by Dr. L. Cockayne, F.R.S., to the effect that a pin point would prove mathematically sound as the basis of a method for charting vegetation. In his researches into the regressing of depleted tussock grassland in Central Otago† he and his assistant, Mr. W. D. Reid, used a point on the toe-cap of one boot as the mathematical point. At the same time I employed a knotted string tightly stretched over a grass sward for charting the vegetation of a typical dairying pasture. From these beginnings has arisen the present point quadrat

*Mr. William Davies spent two years in New Zealand at the Plant Research Station. He brought with him the experience of the Welsh Plant Breeding Station at Aberystwyth, and by personal association with the work proved of immense value in helping to place the strain-testing work in New Zealand on a sound footing.

†Aims and methods in the study of vegetation, ed. A. G. Tansley and T. F. Chipp, London, 1926. "Tussock Grassland Investigation in New Zealand," by Leonard Cockayne, p. 352.

method evolved by the writer and his assistant, Mr. E. A. Madden. The method consists in taking a number of points at random and in recording all vegetation that is hit as the point is projected from above into the sward. The apparatus used is a frame, mounted on legs pointed to facilitate pushing into the soil, and carrying a row of steel pins (hat pins serve excellently) 2 inches apart so held that they slide up and down in a set course (Fig. 4). The number of pins is simply to facilitate charting, and to avoid removing the pin from the slot each time a new point is being examined. The apparatus used at this Station actually makes a line transect of 10 points, 2 inches apart. The number of needles, however, is quite immaterial provided a sufficient number of points are taken. For charting a pasture sward where the dominants only are required 100 points are sufficient, but where it is necessary to record the lesser constituents also 400-500 points are required.

In recording "hits" as the needle descends, all species so hit are recorded in any one downward projection. Thus the needle point may contact a ryegrass leaf in the upper storey, a cocksfoot leaf a little lower down, and in the bottom storey a white clover leaf. These three species are all recorded as covering the unit point of ground covered by the descending needle. Thus for every 100 points examined more than 100 points of vegetation may be charted, according to the number of storeys and species of vegetation present in the sward. It will be noted that the method as defined above is a species ground cover method. By recording every leaf hit irrespective of whether the same or another species, the relative percentage of each species in the sward may be ascertained, but these analyses require more time.

In setting out the results of the analyses there are four main issues involved:

- (1) The percentage of ground covered by each species.
- (2) The percentage cover each species is contributing to the total area. (1st storey + 2nd storey + x storeys + bare ground.)
- (3) The relative frequency of each species in the pasture sward.
- (4) The percentage that each species is contributing to the pasture sward.

The following short exposition of these may make their application clearer.

(1) *The percentage of ground covered by each species.*

These data are secured by recording in each downward projection all species hit and in expressing these in terms of percentage for every 100 points examined. It will be realized that, in a dense pasture with several dominants occupying different storeys, the sum of the percentage of ground covered by each species plus the percentage of bare ground in any one analysis will exceed 100 for the reason that one or more species are covering the same unit of ground. This is exemplified in Analysis A, Series 1, in table 1 below. Here 51 per cent of the ground is covered by ryegrass, 15 per cent by cocksfoot, 19 per cent by white clover, 8 per cent by *Poa pratensis*, 18 per cent by weeds, and 19 per cent of the ground is bare of vegetation, a total of 130 recordings per 100 points examined.

(2) *The percentage cover each species is contributing to the total area. (1st storey + 2nd storey + x storeys + bare ground.)*

This information is secured from the ordinary 100 point analysis in (1) above by application of the following formula:—

$$(\text{No. of times a species is hit per 100 points examined}) \times (100 - \text{percentage bare ground}).$$

Total times vegetation is hit per 100 points examined.

Thus in Analysis B, Series 1, in table 1, of the total area examined perennial ryegrass is contributing to that total 37.2 per cent, cocksfoot 11.0 per cent, white clover 13.9 per cent, *Poa pratensis* 5.8 per cent, weeds 13.2 per cent, bare ground 19 per cent = total 100 per cent.

(3) *The relative frequency of each species in the cover:*

This information is secured by examining the vegetation storey by storey and in recording every hit as the needle descends, irrespective of whether the same or a different species is hit.

Thus in Analysis C, Series 1, in table 1, ryegrass in all storeys has been hit 72 times, cocksfoot 21 times, white clover 19 times, *Poa pratensis* 10 times, and weeds 19 times per 100 points examined.

(4) *The percentage each species is contributing to the pasture sward:*

This is secured by computing percentage composition of sample based on the number of hits of each species in relation to the total number of hits of vegetation according to the following simple formula:—

$$\frac{\text{No. of times a species is hit}}{\text{Total times vegetation is hit.}} \times 100.$$

Thus in Analysis D, Series 1, in Table 1, 51.0 per cent of the vegetation is ryegrass, 14.9 per cent is cocksfoot, 13.5 per cent is white clover, 7.1 per cent is *Poa pratensis*, and 13.5 per cent is weeds=total 100 per cent.

This latter analysis should agree fairly well with actual weight analyses of the component species on separation, assuming bulk for bulk a pin point volume of ryegrass weighs the same as a pin point volume of cocksfoot, white clover, etc. This analysis should also agree fairly closely with the table analysis (F) of the plucked herbage, provided all vegetation is plucked when collecting the sample. This proviso also applies in the case of the cut herbage from which the dry weight determinations of the component species were made. The following analyses of a mixed pasture sward by the point quadrat method done in the ordinary way and in storeys indicate the style of analyses possible by this method. Samples of herbage were plucked for separation and percentage determination and a point analysis of this plucked herbage spread out evenly on a table was also made.

Table 1.—Style of Analysis and Application of the Point Method.

Analyses.	Series.	Component Series.					
		Rye-grass.	Cocks-foot.	White clover.	<i>Poa pratensis</i>	Weeds.	Bare ground.
A. Ordinary point analysis "hits" per 100 points examined=percentage ground covered by each species.	1	51	15	19	8	18	19
	2	52	25	23	15	18	11
	3	52	13	19	9	29	16
	Average	51.6	17.6	20.3	10.6	21.6	15.3
B. Ordinary point analysis reduced to percentage cover basis=percentage cover each species is contributing to the total area. (1st storey + 2nd storey + x storeys + bare ground.)	1	37.2	11.0	13.9	5.8	13.2	19
	2	34.8	16.7	15.4	10.0	12.0	11
	3	35.8	9.0	13.1	6.2	19.9	16
	Average	35.9	12.2	14.1	7.4	15.0	15.3
C. Point analysis in storeys; "hits" per 100 points examined=relative frequency of each species.	1	72	21	19	10	19	19
	2	75	26	24	18	18	11
	3	79	16	20	10	30	16
	Average	75.3	21	21	12.6	22.3	15.3
D. Point analysis in storeys reduced to percentage basis=percentage of each species in the sward.	1	51.0	14.9	13.5	7.1	13.5	19
	2	46.6	16.1	14.9	11.2	11.2	11
	3	51.0	10.3	12.9	6.5	19.3	16
	Average	49.6	13.8	13.7	8.3	14.6	15.3
E. Percentage actual dry weight of component species on separation.		50.8	13.9	12.9	9.2	13.2	—
F. Point analysis of plucked herbage spread out on table.	1	34	19	21	12	14	—
	2	59	13	8	9	11	—
	3	40	18	14	10	18	—
	Average	44.3	16.6	14.3	10.3	14.3	—

(Analyses by Mr. E. A. Madden.)

Prior to adopting the method in field practice trials were made in 1925 in estimating area occupied by coloured cards spread out in two storeys deep on a table. Cards of five colours were used, each card 15 sq. inches. The size of these cards was unduly large, particularly in the case of the less dominant colours, making probably too few replications to give a thoroughly reliable estimate of cover as far as the lesser constituents are concerned.

By measurement and calculation :

Area of table		=	2006 sq. in.
Area of table actually covered by cards		=	1095 " "
Area of table not covered=bare ground		=	911 " "
Area of table covered twice by overlapping cards=2nd storey cover		=	150 " "
Percentage of table not covered=bare ground		=	45.4 per cent.
" " " covered		=	54.6 per cent.
Percentage of table covered twice by overlapping cards		=	7.5 per cent.

By determination by point analysis :

Ten analyses of 100 points each (=1000 points examined) were made and the colours in each analysis were then totalled and averaged for the whole series with the following results :—

Table 2.—Application of Point Analyses in Determining Experimentally Relative Cover and Percentage Composition.

Colour of Card.	Analyses A. Percentage area covered by each colour.		Analyses B. Percentage cover each colour is contributing to the total area. 1st storey + 2nd storey + x storeys + bare ground.		Analyses C. Percentage of each colour in the covered area.	
	By measure- ment and calculation.	By point analysis.	By measure- ment and calculation.	By point analysis.	By measure- ment and calculation.	By point analysis.
Pink	19.4	20.2	17.1	18.2	31.1	31.8
White	18.7	18.7	16.4	16.9	30.1	29.4
Blue	9.0	9.9	7.9	8.9	14.5	15.6
Green	7.5	6.1	6.6	5.5	12.1	9.6
Purple	7.5	8.6	6.6	7.8	12.1	13.5
Bare surface ..	45.4	42.7	45.4	42.7		

It will be noted that the total percentage of table covered in analyses A is greater than that actually obtained by taking the sum of the colours, plus the bare ground, since two colours at the one time when placed in storeys cover the same pin point of surface. The figures in Analyses B=100 per cent, and are derived by applying the formula given under (2) in the foregoing analyses (Table 1).

The first published analyses made by the point method are contained in my paper "The Grasslands of New Zealand," *New Zealand Journal of Agriculture*, Vol. 34, pp. 147-148, 1927; further references may be found in the same Journal, Vol. 35, pp. 363-374, 1927, Vol. 38, pp. 117-121, 1929, and Vol. 40, pp. 363-385, 1930.

G. Einar Du Rietz, Uppsala, in "Vegetationsforschung auf Sociationsanalytischer Grundlage" [Studies of Vegetation on the Basis of the Analysis of Sociations], published in Berlin, 1930, page 412, refers as follows to the point method :—

"If we carry to its logical conclusion the development of quadrat methods in the direction of ever smaller quadrats, as we have followed it above, we come to the substitution of points for quadrats. A. H. Cockayne and Bruce Levy have done this, and have devised a method for the exact analysis of New Zealand pastures, which may conveniently be called the New Zealand

point-method. The point-method has been worked out for the analysis of the field-layer, and obviously is not concerned with the higher layers. It has the great advantage over many other methods that the vegetation of the investigated area is very little damaged. It gives a higher exactitude in comparison with the method of counting individuals, and the line and strip methods, inasmuch as personal opinions are not forced on the worker. In the analysis of the field-layer it has an advantage in exactitude over the quadrat method, since a differentiation of even the densest species is rendered easily possible. Also the needles disturb the natural lie of the plant-shoots much less than does the quadrat, and the method removes the difficulty experienced in the quadrat method of projecting the different plant-shoots of the often dense field layer on to the superimposed quadrat system.

"The point-method requires no more time than the other exact methods, apparently less. In my opinion it has good prospects of becoming the generally used method in the future for exact field-layer analysis."

A modification of the New Zealand point method has been applied also by Bertil Lindquist in his treatment of the field-layer communities within the Scandinavian beech forests [Den Skandinaviska Bokskogens Biologi (The Ecology of the Scandinavian Beech woods) *Särtryck ur Svenska Skogsvårdsföreningens Tidskrift*, Häfte 3, 1931]. The following extracts relate to the methods:—

P. 203: "Since one of the chief aims of this work has been the study of the correlation between the field-layer synusia and the habitat, it has naturally been necessary to analyse the vegetation of the field-layer by the use of a method that as regards exactitude and objectivity corresponds as much as possible with the one that had naturally to be used in the study of the habitat. I have therefore not thought I should content myself with the more extensive method prevalent in Scandinavia of estimating the frequency of the different species by the help of the five-graded cover-scale (Hult 1881, Sernander 1894, 1900, 1921, etc., Du Rietz, 1921, 1930). Concerning the hitherto existing methods for exact analysis of the field-layer, it will be sufficient to refer here to the recently published critical synopsis of Du Rietz (1930, pp. 400-414). Since not only the method of weight-analysis but also the planimeter method of determining the grade of cover given by the different species tested by Skottsberg (1929) suffer from the fault that 'the results attained do not stand in reasonable proportion to the work involved' (Skottsberg, 1929, p. 60) I could only concern myself with the different methods of exactly determining the density.

"Of these methods I found, like Du Rietz, only that evolved by A. H. Cockayne and E. B. Levy—the point method—to give satisfactory results in the analysis of the field-layer.

"On the basis of the principle of this method, therefore, I worked out a new method that I have used since the spring of 1929 in my analyses, in place of the Hult-Sernander and Raunkiaer methods that I had used previously.

"Instead of the line-frame with 10 rods used by Cockayne and Levy, a quadrat frame 1×1 metres in area, with 100 rods evenly spaced over it, was used. Points in this square frame were obtained by an arrangement quite comparable with that of Cockayne-Levy. From a horizontal bar descended 10 rods evenly spaced. This bar, which rested upon two legs attached to the square laid out on the ground, was movable along two sides of the square. In the analysis is first registered the vegetation at the 100 points, so that the bar has to be moved ten times along the sides, holes marking the exact place for each reading. It has not been practicable to bring the 'points' down to the smallest possible size. After various experiments with different diameters, I decided to use rods 3.5 mm. diam., because it was difficult to obtain thinner material that would withstand the shocks to which the apparatus is liable in use.

"It must be emphasized that results fully comparable to those published here can only be obtained by using rods of the same diameter. Rather different results should be obtained if one worked with a rod-diameter approaching that of a mathematical point.

"To be capable of registering a tall herbaceous vegetation the rods were made 1 m. long. With this apparatus I was thus able to determine the frequency of the species coming within the square, which is given by the number of rods (1-100) touched by each species.

"After this exposition of the manner of using the new method, and of its possibilities, I think that without further investigation it can be used for plant-sociological purposes, especially as the

mean error in registration seems somewhat small. In the researches I have carried out by this method since 1929, it has shown itself in all respects extremely useful.

"Perhaps the chief advantage of the method lies in the fully objective nature of the work. It gives, moreover, well differentiated frequency determinations for every species. . . . This gives us now, for the first time, the power to follow in detail and with full objectivity the development of a test area from day to day, from year to year. It facilitates further the determination of mixed occurrences of species that because of their outer similarity can with difficulty be separated in the non-flowering conditions, e.g., *Anemone nemorosa* and *A. ranunculoides*. . . . Finally it should be an advantage in the method that the analysed plant community is in no way damaged in the investigation. The method has, however, certain disadvantages. In a community rich in species an analysis of this kind takes a rather long time, from a half-hour to an hour."

7. Photography.

I have found the camera an indispensable recording tool and I would recommend its extended use to all research workers. A good photograph presents an eye picture: with tables and descriptive matter a mental picture alone is possible. To the non-scientific reader particularly, large tables and complicated graphs are almost impossible of interpretation; but a good photograph, well reproduced, is readily appreciated. As an inducement to research, the camera is an extraordinarily valuable ally. In research one is bound to have what may be termed "working hypotheses" and the camera, provided a worker is honest, affords the greatest test as to the truth or otherwise of such an hypothesis, speaking more particularly in an ecological sense. Can such and such an hypothesis be illustrated pictorially? If it can be well illustrated obviously it is sound. If it is incapable of pictorial representation, then it is obviously unsound excepting, of course, where differences are too small to be appreciated by eye. In the ecological grassland work performed during the last 20 years, I have always carried a camera and it has helped to accumulate a sound ecological outlook more than any other single factor—including note-taking. The camera used is a $\frac{1}{2}$ -plate standard Thornton Pickard stand camera. Certain movements in such a camera are essential: the back must be capable of a backward tilt and the lens of a forward tilt. This enables objects far from camera and close distant objects to be brought more or less into focus at open aperture. Also there must be an adjustment so that the back carrying the ground glass may be moved out of parallel to the lens front by a forward or backward move of either side. This enables objects at varying distances right or left to be better brought into focus at open aperture. A good lens is essential and a sufficiently long bellows to enable objects to be taken at natural size at least. I use for outdoor work a film pack and verichrome films as giving a good even grade of negative and good detail in shadows. Probably the secret of success in close-up views of turfs, single plants, etc., is to photograph only when the sun is well hidden by clouds. Close-up photographs are useless as far as detail is concerned when taken in direct sunlight. The high lights are overstrong and there is no detail within the shadows. Best results are secured in general by stopping well down and over-exposing rather than under-exposing. Exposures and stopping down are a matter of practice. I view everything I take on the ground glass as I stop down. In this way exposures may be better judged and the correct stop used to bring out clearly the object to be photographed. Thus in some cases great depth is required, while in other cases the object is shown to best advantage if the background is well out of focus. By stopping down over much and thus bringing the background into focus in such cases, the outline of the object desired to show is lost in the background.

It is my experience that a research worker who wishes to illustrate his work must learn to take his own photographs. Opportunities in the field for good photography are comparatively rare, and many a good photograph is missed unless the worker himself on the spot can use the camera. Development, printing, recording, etc., may well be left to the staff photographer, an officer in my opinion indispensable to a research station. In photography I regard the photo as part of the record rather than as a piece of technical skill in the actual setting up of the camera, focusing, snapping, etc. The most difficult part in photography is to depict on the plate the point which it is desired to illustrate. Many photographic records lose their value in the endeavour to crowd too much into the one photograph.

In acknowledging a photograph in a publication, it should be stressed that the value of the photograph is more in what is illustrated rather than in the mere technical skill required in actually taking the photograph. Nevertheless, if all photographs are not acknowledged there is left open great scope for piracy. Where a research worker chooses a subject and calls upon a photographer to take the photo it would probably be more suitable that the acknowledgment should include both workers, the name of the research worker coming first and the person actually taking the photograph last, using surnames in both cases.

UPKEEP OF RESEARCH AREA.

Too much emphasis cannot be placed on the need for manual labour and what may be termed manual technical assistants. The function of the latter is largely the raising of single plants, propagation of material; labelling of plots; topdressing; tending to stock; sample weighing; seed cleaning, etc. In any work demanding upkeep of an area the specialist is limited in his scope by the amount of manual labour available. Scrupulous cleanliness and unremitting care in upkeep are just as essential in the field as in the laboratory.

Two labourers and one technical assistant given every mechanical assistance possible in the form of light motor tractors, Planet Junior cultivator, etc., are the minimum requirement for 6 acres of land specifically set aside for strain testing and strain building work.

FIELD TRIALS.

These are conducted on the leading soil types throughout New Zealand. From the preliminary plot trials at the Palmerston North Station strains are determined and selections made. Plot testing these and the progeny on a field scale under normal farm grazing is now carried out according to the field organization and general technique outlined in paper 3. Production trials of all selected lots are also being undertaken against standard material under the Hudson system of mowing and grazing. This system, together with general field technique, is fully dealt with by Mr. A. W. Hudson in paper 3.

OVERSEAS TRIALS AND UNIFORMITY OF TECHNIQUE.

Over 1,000 samples representing New Zealand strains of herbage plants were despatched overseas last year for collateral trial with the same lots tested in New Zealand. The creation of uniformity in these trials throughout all stations is a piece of technique in organization which it is hoped will arise out of the issue of these technique Bulletins. Species, strain, fertility and utilization are basic factors in grassland economy, and a uniformity of technique based on these four factors is urgently needed for testing of the same species or strains collaterally among grassland workers of the world; then, and not till then, shall we be able to say one's own stock is the best for one's own country.

Acknowledgment.

The author is indebted to Dr. H. H. Allan for assistance with certain German and Swedish papers.

TITLES TO ILLUSTRATIONS.

- FIG. 1.—General view of white clover plots after the rows have joined up to form a "broadcast" plot. With white clover it is essential to have lots divided by a strip 1 ft. wide that is kept cultivated.
Photo. E. BRUCE LEVY.
- FIG. 2.—General view of red clover and white clover single plant trials showing layout. The white clover sections are 10 plants wide, the strip between being laid down permanently to grass. The red clovers in the foreground are occupying an odd corner and the rows are of varying length, in most cases being much too long for ease of note-taking. The 10 plant row is ideal for this purpose.
Photo. E. BRUCE LEVY.
- FIG. 3.—An area of ryegrass single plants. Each section 10 plants wide with a 5-link division between each section. Broadcast ryegrass plots on the left. The trial depicted is one comparing mother seed lots and their progeny grown outside the district of origin of the mother seed itself.
Photo. E. BRUCE LEVY.
- FIG. 4.—Using the point analyser in connection with turf establishment in connection with the New Zealand Greenkeeping Research work at Palmerston North. A "kneel on" rubber pad is a valuable part of the outfit.
Photo. E. BRUCE LEVY.
- FIG. 5.—Laying down a field trial under the Hudson system of alternate mowing and grazing. A good team is essential in order to complete sowing of a large trial in the one day.
Photo. E. BRUCE LEVY.



PAPER No. 1. [E. B. Levy]

FIG. 1.



PAPER No. 1. [E. B. Levy]

FIG. 2.



PAPER No. 1. [E. B. Levy]

FIG. 3.



PAPER No. 1. [E. B. Levy]

FIG. 4.



PAPER No. 1. [E. B. Levy]

FIG. 5.

2.—THE CERTIFICATION OF HERBAGE SEEDS IN NEW ZEALAND.

J. W. HADFIELD.

Agronomist, Plant Research Station, Department of Agriculture.

Research in regional strains and in the production of nucleus lines of seed of particular merit is not infrequently nullified through the lack of an organization for commercializing its results. Although we have hardly reached the stage of commercialization of the results of plant breeding and selection of herbage plants in New Zealand, we have nevertheless certain regional strains of sufficient merit to warrant control of the distribution of such seeds. For this purpose we have adopted a system of seed certification, the object of which is to ensure the accurate description and wider distribution of superior strains of grasses, clovers, and other farm seeds. The result has been a considerable expansion in the area sown with these better strains, and a wider recognition of their value both within the Dominion and in overseas markets. As it is not possible to discuss each crop separately, the general account of certification given here must be taken as subject to many exceptions and modifications to meet the specific requirements of each.

It would seem that an organization must be moulded to meet the trade requirements of the particular country in which it is being introduced. For this reason one may perhaps be permitted to make brief mention of the trade organization in this country.

We have very few seed-growers' associations and these few are not selling organizations. Virtually the whole of the seed is handled by merchants and co-operative companies who obtain their supplies either by growing on contract or by competitive buying from the farmer. These firms machine-dress the seed, and it is they who, having a complete knowledge of trade requirements, distribute the finished product both within and without the Dominion. To a large extent these same firms finance the grower and are directly interested in the success of his farming operations. They hold, therefore, a very strong and important position, and co-operate in every possible way with the Department of Agriculture in the advancement of agricultural practice. Since the grower will receive in due course his share of any improvement in trade we pay as much attention to the requirements of the merchant firms as to those of the farmer, and at all times avoid any action that might unduly disturb the usual channels of trade. In this atmosphere of mutual confidence and co-operation, seed certification has flourished and has met with the whole-hearted support of the four parties interested, namely, the research worker, the producer, the merchant and the consumer.

ORGANIZATION.

The Fields Division of the Department of Agriculture consists of four Fields Superintendents controlled by a Director. Working under each Fields Superintendent are agricultural instructors who, stationed at convenient centres, perform in addition to their other duties those associated with seed certification.

The seed certification activities of the Fields Division are organized by the Agronomist in co-operation with other officers of the Plant Research Station, notably the Agrostologist and Seed Analyst.

For the convenience of the work, New Zealand is divided into 23 certification districts, each under the supervision of an agricultural instructor, who, for the purpose of seed certification, virtually becomes an inspector. The instructor maintains a complete record of all certification in his district, and the Fields Superintendent keeps a record of all certification in the districts within his supervision. In the office of the Agronomist is maintained a central record of all operations throughout the Dominion. There all returns are checked, and advice given on any problem that may arise so that a smooth running organization is maintained.

Each district is distinguished by code letters; each farm growing certified seed receives a registered number, and each field on the farm carries a distinguishing letter. A plan of each

farm is prepared, showing subdivisions, the area of each field, and the age of the pasture. Thus it becomes a simple matter to trace any line of certified seed to the field of origin. For example, HB/156-D indicates that the seed originated from field D, being part of registered farm 156 in the Hawke's Bay district. Moreover, a file is opened for each unit or field when it is first entered for certification, and thus all returns, reports and correspondence relating to that particular field from the time of its entry are kept together in a readily available form.

SAMPLE TRIALS.

Every sample of seed sent in for trial with a view to certification must have a known origin. Samples submitted by growers or merchants are not accepted for the purposes of certification. It is the duty of the agricultural instructor to draw such samples and submit them for trial, supplying at the same time details as to origin. These samples are recorded and passed over to the Agrostologist for trial, who in due course furnishes a report to the Agronomist.

With certain exceptions an area is not eligible for certification unless a sample of seed harvested has been grown under trial and a satisfactory report furnished thereon.

The following herbage plants are at present subject to certification :—

N.Z. Certified	Perennial Ryegrass	(<i>Lolium perenne</i>).
" "	White Clover	(<i>Trifolium repens</i>).
" "	Brown-top	(<i>Agrostis tenuis</i>).
" "	Cocksfoot	(<i>Dactylis glomerata</i>).
N.Z.-grown Certified	Montgomery Red Clover	(<i>Trifolium pratense</i>).
" "	Kentish Wild White Clover	(<i>T. repens</i>).

IDENTIFICATION AND PURCHASE OF CERTIFIED SEED.

Certified seed carries within the sack an insert slip, and on the outside a certification tag. The twine used for sewing the mouth of the sack is threaded through the certification tag and the ends sealed with metal seals. It is therefore not possible to open the mouth of the sack without either cutting the twine or damaging the seals. On the tag is recorded the registered area from which the seed was harvested, making it possible to trace each line back to the paddock of origin. The tag also bears the number of the purity and germination certificate covering that particular line of seed.

It is of great importance that purchasers should realize that certification of ryegrass seed refers to type, but gives no warranty as to purity and germination.

For each line of certified machine-dressed seed a purity and germination certificate is issued by the Seed-testing Station, and the purchaser is expected to protect himself by inspecting this certificate, which records the percentage of pure seed, the percentage of pure germinating seed and the nature of the impurities. These certificates are held by the vendor of the seed.

The insert slip is to be found inside the mouth of the sack, and bears the same information as is found on the certification tag. These slips are of particular importance to the purchaser who intends to sow the seed with a view to further seed production under certification. He is expected to retain these slips as evidence of having purchased this seed, and submit them with his application for the certification of the resulting progeny.

CLASSIFICATION.

Mother seed :

This class of seed is intended specifically for the sowing of areas in connection with further seed production. The following conditions must have been complied with before seed may attain to the mother class :—

1. The pasture from which the seed was harvested must be 5 years old or over, and a sample of seed from that pasture must have been under test and found to be of a sufficiently high standard as to warrant the pasture being declared a "Mother Seed Area."
2. At the annual field inspection the seed crop must attain the standard laid down for mother seed.
3. The machine-dressed seed must attain a reasonable standard of purity. Failing this it may be redressed to the requisite standard, or rejected.

Permanent pasture seed :

This class of seed is recommended for the sowing of pastures not intended specifically for seed production. The following conditions must have been complied with before seed may attain to the permanent pasture class :

1. (a) The area from which the seed was harvested must have been sown down with mother seed ;
- or (b) A sample of seed from the area must have been under test and found to be of a sufficiently high standard as to warrant the pasture being declared a " Permanent Pasture Seed Area."
2. At the annual field inspection the seed crop must attain the standard laid down for permanent pasture seed.
3. The machine-dressed seed must attain a reasonable standard of purity. Failing this it may be redressed to attain that standard or rejected.

AREAS ELIGIBLE FOR INSPECTION.

1. Any area rejected on type report is not permitted entry unless a later report indicates a satisfactory standard.
2. An area rejected at field inspection may be re-entered provided it has not been rejected also on type report.
3. Any area sown with mother seed is eligible for entry in the permanent pasture class for the first harvest without the necessity of a type report.
4. Any other area to be eligible for entry must have had a sample therefrom tested and reported upon as of certification standard.

FIELD INSPECTIONS.

If eligible the application is accepted and the field inspected in due course. A special technique of field inspection has been evolved ; the inspector has available a plan of the farm, past sample trial, and field inspection reports of the area, all of which facilitate the work of inspection. The training of officers to undertake these duties has not proved as difficult as might be supposed. Training has extended as certification has progressed, but the initial step was to train one officer under each Fields Superintendent.

The grower is advised of the result of the field inspection, and if the area is passed the responsibility rests upon the grower to give the inspector due notice of his intention to thresh.

PADDOCK SEALING.

The inspector attends at threshing, and seals and brands the sacks as they come from the threshing mill. Code letters and numbers are used as brands to indicate the year of harvest, the nature of the contents of the sack, and the field, farm and district of origin.

Thus a sack branded :

3 H B
153 D F
Z T

would indicate that the sack contained mother seed perennial ryegrass (Z), and an appreciable quantity of white clover of permanent pasture standard (T) sufficient to warrant the special dressing of this seed should the merchant so desire. Further it indicates that fields D and F were threshed together from the registered farm number 153 in the Hawke's Bay district in 1933 (season 1932-33).

Each sack is sampled and a blend of the sample forwarded to the Agronomist, together with full details of brands and weights. The sample is used for plot trial or ultra-violet ray test as may be deemed necessary, and affords a check on type and an indication for future action in regard to that area.

At this stage the Department loses contact with the seed until in due course an application is received from a merchant desiring to machine-dress the seed.

MACHINE-DRESSING.

On application an officer attends the dressing plant, removes the seals from the sacks, takes inward weights, and supervises the blending, if such is necessary. All information the inspector needs is already branded on the sack. Machine-dressing then proceeds. When completed all outward weights are taken and loss in dressing accounted for. An insert slip is then placed in each sack. The outer tag is threaded on to the seaming twine during sewing, and the twine is then sealed at both lugs of the sack. Both the insert slip and the outside tag carry all information required, namely, the kind of seed, the classification and origin, and the number of the purity and germination certificate which, when prepared, will accompany the line.

A sample is then drawn from the top, middle, and bottom of each sack, and a blend of this is forwarded direct to the Seed Analyst for purity and germination certificate. The Seed Analyst draws his requirements of seed, and the balance is passed on to the Agronomist to arrange for such other trials as may be necessary. The samples are held for two years as evidence in the event of any dispute.

The P. and G. certificate is forwarded direct to the owner of the seed, such certification forming a compulsory feature of seed certification.

SCALE OF CHARGES.

These vary according to the kind of crop, but taking perennial ryegrass as an example the following charges are made :—

1. Entrance fee 10s.
2. An excess area fee of 1s. per acre must be paid for each acre in excess of 10 acres.
3. The machine-dressing fee is at the rate of (a) 1½d. per bushel, or (b) 6d. for each sack that is sealed, whichever is the greater amount when computed over the whole line.
4. A charge of 2s. is made for a P. and G. certificate, and 3d. for each additional copy issued.

During the initial stage certification services were free. With the introduction of the above scale of charges some concern was felt as to its possible effect upon the progress of the scheme. In point of fact the introduction of charges seemed rather to have stimulated interest and to have created a better realization of the value of the services rendered. For example, perennial ryegrass certification under free services rose from 3,028 acres in 1929-30 to 6,539 acres in 1930-31. Charges were introduced for the first time for the season 1931-32, when the area increased to 9,709 acres, and during the current season (1932-33) it has risen to approximately 23,000 acres.

TITLES TO ILLUSTRATIONS.

FIG. 1.—Plan and individual field records of a farm producing certified seed.

FIG. 2.—Tags that are attached to the outside of all sacks of New Zealand certified seeds.

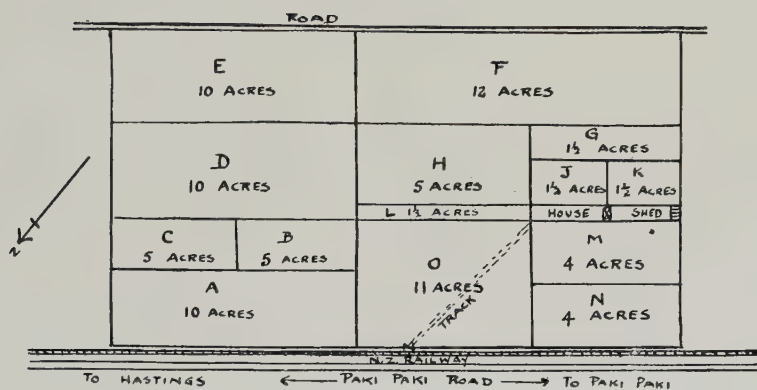
Photo. H. DRAKE.

FIG. 3.—The purity and germination certificate covering a line of machine-dressed certified seed. The number of the certificate in the case illustrated 61/HB appears also on the tag attached to the sack.

Name: STRUTHERS A.

Address: LONGLANDS

Regd. No. H.B.7

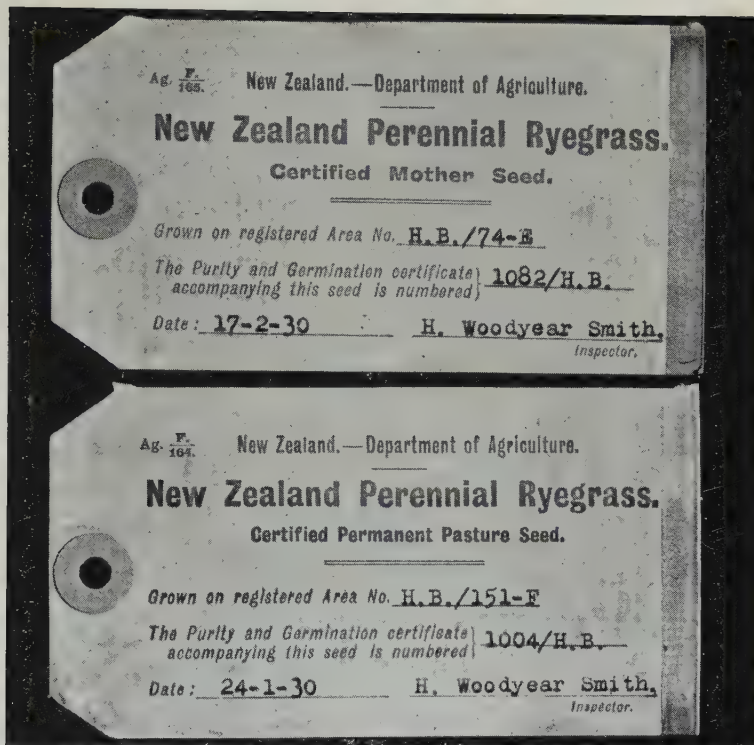


Name: STRUTHERS, A. Address: LONGLANDS. Regd. No. H.B.7.

General History: Topdressed with two cwt. Super each season and harrows.

Paddocks:

- A. area 10 acres Lucerne old stand 1929.
- B. area 5 acres sown about 1890. Harvested 1928-29.
- C. area 5 acres sown 1924 with own seed.
- D. area 10 acres sown about 1890. Last harvested 1919.
- E. area 10 acres sown 1922 with O.P. seed from Evans Pukahu. Harvested 1927-28.
- F. area 12 acres sown about 1890. Harvested 1928-29.
- G. area $1\frac{1}{2}$ acres Lucerne.
- H. area 5 acres sown 1920. Harvested 1927-28.
- J. area $1\frac{1}{2}$ acres sown 1924. Not harvested.
- K. area $1\frac{1}{2}$ acres sown 1924. Not harvested.
- L. area $1\frac{1}{2}$ acres. Bull paddock.
- M. area 4 acres sown about 1890.
- N. area 4 acres Lucerne 1929.
- O. area 11 acres sown about 1890. Harvested 1928-29.



PAPER No. 2 [J. W. Hadfield]

FIG 2.

NEW ZEALAND DEPARTMENT OF AGRICULTURE,
SEED-TESTING STATION. (Original)

CERTIFIED SEED. Palmerston North,
31st April, 1930.

Certificate of Analysis No. 61/H.B., accompanying Thirty-four sacks
N.Z. M/D Perennial Ryegrass, certified Permanent Pasture, harvested from
Registered Area No. H.B./67-M.H.Q.

Station Test No. 30/1200 Sample received 21.4.30 Test completed 31.4.30

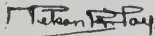
PURITY.		GERMINATION CAPACITY	
Pure seed	98.9 %	Interim count	84.0 % in 6 days.
Other crop seeds	0.2 %	Final count	88.0 % in 10 days.
Weed seeds	0.2 %	Hard seeds	- %
Inert matter	0.7 %	Pure germinating seed	87.0 %

Other crop seed—Species: Dactylis glomerata: Trifolium repens: Holcus lanatus.

Weed seeds—Species: Festuca bromoides: Bromus hordeaceus: Rumex crispus.

Additional particulars:

The above analysis has been made in accordance with the provisional Testing Rules (S.M.) issued by the International Seed-testing Association.


 Seed Analyst.

10-2-30/10/30-10/30/30

PAPER No. 2 [J. W. Hadfield]

FIG 3.

3.—MEASUREMENT OF PASTURE PRODUCTION : EXTENSION AND DEMONSTRATION FIELD TRIALS.

A. W. HUDSON.

Crop Experimentalist, Plant Research Station, Department of Agriculture.

CONTENTS.

- A. Introduction.
- B. Alternate mowing and grazing technique.
 - (1) The use of the lawn mower and the influence of mowing-only on the pasture.
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A.—INTRODUCTION.

In this section it is intended to indicate briefly the principal methods adopted by the Department of Agriculture. The main objectives of the work are (1) to obtain as reliable information as practicable under the circumstances surrounding each project or system of experiment, and (2) to incorporate into farm practice as rapidly as possible those findings which are considered sound from an economic point of view. The organization which assists in the realization of the latter is described in broad outline in Part E of this paper.

Because of the diversity of methods and degrees of perfection in the management of grassland as influenced by soil, climate, systems of farming, personal and other factors, it is sometimes difficult to decide upon a satisfactory technique for the measurement of grassland production. Obviously the problem itself and the nature of the answer required must have a considerable influence in determining the technique, and while one technique may be ideally suited to solving one particular problem a different technique may be required for some other problem. In describing the various methods adopted in New Zealand the writer hopes that at least some of the methods may find application or that some of the points discussed may be of assistance to workers in other countries.

Some attention has been given in this article to a description of the technique of "alternate mowing and grazing," because nearly five years' experience in its use indicates that it is ideally suited to the investigation of certain fundamental problems. Chief amongst those already investigated or in process of investigation are : (1) the effect of time of application of phosphatic and nitrogenous fertilizers on seasonal production, (2) a comparison of infrequent heavy dressings versus frequent light dressings of phosphate and lime, (3) a comparison of the effect of

different carriers of phosphate and nitrogen, (4) a comparison of the newer concentrated compound fertilizers with simple mixtures. (The results of some of these investigations have been published in Bulletin No. 31 of the N.Z. Department of Scientific and Industrial Research.)

The alternate mowing and grazing technique is now being applied to the determination of the relative yielding capacities of different ryegrass, cocksfoot and clover strains as constituents of pastures, actually an extension of the work of the Agrostologist.

Such problems are concerned as much with the influence of treatments at different seasons of the year as with their total effect, and the use of any other method such as grazing trials would have involved large areas, large numbers of stock, large errors, and a high expenditure and labour outlay, all of which have been reduced to comparatively small dimensions by the technique adopted.

What is considered to be the main objection to the technique is discussed in Part C of this article, and an alternative method of procedure is suggested as a means of overcoming this objection.

In investigations of the type cited, the economic aspect does not play an important part because one of the main objects is to determine the best method of using something which is already recognized as being of considerable economic value on the soil under investigation. In any case there is a grave danger in attempting the investigation of the economic value of a fertilizer, for example, at any one particular place. Experience has taught us that although a particular type of soil under particular climatic conditions may respond everywhere to a certain fertilizer application, the degree of response may vary considerably from one paddock to the next or from one farm to the next. The previous management, the nature of a sward or its management, or the personal element, may have a considerable influence on whether a practice pays or does not pay. It is the opinion of the writer that the economic aspect of any investigation should figure prominently only where such investigation is represented by a sufficient number of individual cases to ensure that the average result is a reasonably representative one.

B.—ALTERNATE MOWING AND GRAZING TECHNIQUE.

The measurement of pasture production under a system of alternate mowing and grazing was discussed by the writer in a recent publication (1). Since the issue of this publication slight modifications have been made in the technique and it is proposed to discuss the technique as now practised on experiments recently laid down. Before doing so, however, the reasons leading up to the adoption of this method of measuring pasture production deserve consideration.

I. THE USE OF THE LAWN MOWER AND THE INFLUENCE OF MOWING-ONLY ON THE PASTURE.

(a) *The use of the lawn mower for measuring pasture production.*

The use of the lawn mower in the Department of Agriculture's pasture investigational work was suggested in 1928 by Mr. A. H. Cockayne, Director of the Plant Research Station. At the same time Mr. Cockayne pointed out that mowing-only caused profound changes in the botanical composition of the sward, and suggested that if stock could be used in conjunction with the mower these changes could be prevented. How this was achieved is described below in Sect. 3b.

(b) *Effect of mowing-only on the botanical composition of a pasture.*

The exclusive use of the mower causes upright-growing species such as grasses to be pruned relatively more severely than species of more prostrate habit of growth such as white clover and "flat" weeds similar to *Hypochaeris radicata* and *Plantago lanceolata*. Consequently the prostrate species become more dominant constituents of the sward under mowing than they do under grazing, where they may be pruned as severely or more severely than upright-growing species.

Further, the mower fails to differentiate between relatively palatable and unpalatable species, with the result that species which, under grazing, may have their production seriously curtailed by excessive defoliation by virtue of their greater palatability, when mown-only may contribute more in proportion than less palatable species.

Figures 1 and 2 show the influence of *mowing-only* versus *mowing plus grazing* on the vigour of a few species in a sward after a period of five months. It will be noticed that grasses represent a much smaller proportion of the total herbage under mowing-only than where subjected to grazing as well. A comparison of these same swards after three years of mowing on the one hand, and mowing plus grazing on the other, shows much the same difference as resulted after five months. During periods, especially in the spring, when rye-grass was making rapid growth, it was obvious that there was very little alteration in the incidence of the different species. The difference between the two systems of management in the case of the sward under discussion was due more to the differences in vigour of the species than to any change in numbers of plants of each, with the exception of the "flat" weeds which definitely increased in number under mowing-only. It should be noted that the principal constituents of the pasture, ryegrass and white clover, were truly perennial strains, and were liberally phosphated throughout the trial.

(c) *Removal of lime, phosphate, potash and nitrogen under a system of mowing-only.*

Since the exclusive use of the mower necessitates the removal of herbage there can be no return of any of the above constituents of the pasture, whereas under grazing a very large proportion is returned in the faeces, the amount depending on the class of stock used.

Actual figures taken from an experiment (2) carried out in New Zealand show that a pasture producing 8,410 lb. of dry matter in a year took up :

84 lb.	CaO.
80 lb.	P ₂ O ₅ .
257 lb.	K ₂ O.
408 lb.	N.

Under mowing-only the whole of this would have been removed from the soil.

A comparison of the two systems of management in their effect on pasture production over a period of three years has been made by the writer. The salient features of this comparison are that two adjoining portions of the same pasture received fertilizer treatment sufficiently similar to warrant their comparison and the regarding of any differences due to the use of fertilizers as being negligible compared with the differences due to management. One area was mown 51 times during the three years, the mown herbage being removed. Each duplicate section on the other area was mown 27 times—giving 54 growth periods—the mowing of one section corresponding with a grazing period of the other, all cut herbage being fed to stock grazing one or other of the duplicate sections as described below in Sect. 3b.

The production for each of the three years resulted as follows :—

Year.	Mowing only.		Alternate mowing and grazing.	
	Green herbage.	Pounds per acre. Dry matter.	Green herbage.	Dry matter.
1929-30 ..	33,756	*	24,100	*
1930-31 ..	36,488	6,610	43,786	7,781
1931-32 ..	28,273	5,469	42,238	8,107

*Dry matter not determined.

The superiority of the area under mowing-only during the 1929-30 season is attributed to a weakness which was overcome subsequently, in the technique of alternate mowing and grazing. This weakness is discussed fully elsewhere (1) and is referred to below. It is obvious from the yields in 1930-31 and 1931-32 that the production was falling away rapidly under the mowing-only, but was being maintained under the alternate mowing and grazing system. The experiment under the latter system is now in its fourth year and under a favourable season for growth will certainly produce more than in the seasons quoted above.

2.—THE LAYOUT OF A TYPICAL EXPERIMENT UNDER THE ALTERNATE MOWING AND GRAZING TECHNIQUE.

A plan of a typical experiment is shown in Fig. 3. Each section occupies an area 117×84 ft. equal to 0.225 acre so that the whole area occupied by the experiment equals 0.45 acre.

(a) *Size of experiment:*

The size of the experiment is governed by practical considerations and is such that under the *least* favourable seasonal conditions the whole of the plots of one section can be cut and weighed in the time available on one day. In order to minimize errors, cutting is not done until the herbage is fairly free from external moisture, and during the spring and autumn this stage of dryness is not generally reached until about mid-day. Cutting out of headlands, the cutting and weighing of plots, and the transfer of herbage from one section to another occupies *two* men from 3 to 4 hours, so that an experiment on which cutting starts soon after mid-day is completed by four or five o'clock in the afternoon. The actual cutting and weighing of the herbage under measurement occupies from 1 to 2 hours, depending upon the amount of growth.

Under favourable weather conditions in the summer it is possible to complete two experiments in one day with a team of two men.*

(b) *Size and shape of plot:*

The size of the individual plot used, namely 35×6 ft., was determined by the amount of material to be handled and the width of the mowing machine. A single plot may yield from 2 or 3 lb. to 18 or 20 lb. of green herbage at a cut, depending on the amount and density of growth. (As explained below the actual area cut from each plot is 60×2 ft.) The weighing of quantities less than 2 or 3 lb. necessitates the use of a delicate balance, or errors are likely to be large in relation to the total quantity. Weighings are made to the nearest 5 or 10 gm. Quantities greater than 12 lb. necessitate an inconveniently large weighing receptacle. As it is, each plot has at times to be weighed in two separate portions.

The width of the plot, 6 ft., is such that two distinct cuts of the 2 ft.-wide-mower can be taken out, leaving a reasonable amount along the middle line of each plot to allow for the passage of the mower wheels (see figs. 4 and 8), and at the sides, to allow for the passage of the mower wheels and possible "edge" effect.

The shape of the plot has proved a convenient one, both from point of view of applying fertilizers and cutting.

(c) *Shape of each section:*

Having decided on a convenient size and shape for the individual plot, the shape of each of the duplicate sections of the trial is a matter of some importance. Two long and narrow sections side by side would be convenient from the point of view of the transfer of cut herbage from one section to the other as described below. The long narrow section, however, is not suitable from the point of view of the grazing of stock on account of the tendency for stock to "camp" at one end, especially if the ground is sloping. The more nearly each section approaches a square the more uniform the camping and grazing tends to be. The dimensions of each section, 117×84 ft., are as near a square as consideration of other factors will permit.

(d) *Frequency of replication and arrangement of plots:*

The experiment illustrated in figure 3 consists of six treatments each replicated six times in each of the duplicate sections, giving a total of twelve replications. Provided the soil is fairly uniform this will give reasonable accuracy. Should increased precision be desired an increase in the number of replications should be accompanied by a decrease in the number of treatments, or the total area involved becomes greater than can be managed conveniently by one team (2 men and 1 mower) in one day during the least favourable climatic periods.

*The ideal team consists of two men and a youth. Duties are allocated as follows:—One man weighs, records and samples herbage; one man operates the mower, and the youth spreads the cut herbage after weighing and assists at times in carrying the herbage from the mower to the scales. With this team two experiments can be cut and weighed in one day with reasonable ease under average conditions.

Reference to figure 3 will show that the arrangement of the plots is such as to give two complete 6×6 Latin squares if the left or right half of one section is taken in conjunction with the left or right half of the other. Obviously the division of the whole area into two separate Latin squares would be the logical arrangement if the point discussed under (c) above did not have to be considered. Unfortunately facilities at our disposal do not permit of statistical examination of all cuts, but there seems no reason why six-monthly or annual plot totals cannot be examined statistically, using the yields from both sections.

No attempt has been made to randomize treatments. The writer prefers a deliberate arrangement in which each treatment in each of the Latin squares falls to right of or above any other treatment the same number of times as it falls to the left of or below it. The arrangement in figure 3 gives this, and, moreover, for the distance between one treatment and any other in a particular row or column, there is a corresponding distance between a similar pair of plots in another row or column, but in the opposite direction. Such an arrangement of the Latin square is possible only where an *even* number of treatments is under trial. Although deliberate arrangement is invalid in the eyes of the statistician, in the opinion of the writer it has advantages which outweigh the disadvantages raised by the statistician without invalidating the interpretation in terms of statistics to any material extent. The controversial nature of this point precludes further discussion in this article.

(e) *Pegging and marking of plots:*

The corners of each plot are marked with hardwood pegs 2 in. $\times$ 2 in. and about 15 in. in length. Each has a zinc label tacked over the top on which the treatment number is stamped and an arrow pointing to the corresponding plot. The pegs stand four or five inches above ground level. Their correct alignment is important for reasons indicated later.

3.—STAGE OF CUTTING, CLOSENESS OF CUTTING AND MAINTENANCE OF PASTURE UNDER STOCK-GRAZING CONDITIONS.

(a) *Stage and closeness of cutting:*

So far as weather conditions permit, cutting is done when the herbage has attained a stage of growth more or less intermediate between that considered suitable for sheep-grazing on the one hand and cattle-grazing on the other. This may entail spelling of the pasture for as little a time as ten days during periods very favourable to growth, or as long as two to three months during the winter.

Following a discussion of the findings at Aberystwyth and Cambridge on the effect of frequency and closeness of defoliation of pasture herbage, and on practical considerations, the writer made the following generalization, (1) "Under a system of rotational grazing the pasture should be spelled for as long as possible between grazings commensurate with good utilization by the stock employed, and care should be taken not to graze the pasture too closely."

The aim has been to follow the principles embodied in the generalization as closely as circumstances permitted.

Cutting is done to within $\frac{3}{4}$ in. to 1 in. from the ground.

(b) *Maintaining the pasture under stock-grazing conditions by alternate mowing and grazing:*

The method described herein has been evolved by various modifications of the original method as the work has progressed. The mower and scale represent the measuring agents and sheep the managing agents. Not only does the grazing ensure that all species are subjected to reduction by stock accompanied by intensive treading for certain periods, but it also permits of all herbage being consumed on the area under experiment. From the point of view of maintaining the botanical composition of the sward in a condition comparable with that of intensive rotational grazing and ensuring the "return of fertility" in the form of animal excrement as would occur under grazing, the methods adopted appear to be entirely satisfactory.

An example of how the alternate mowing and grazing operates is shown in tabular form below :—

Both sections closed on 1st day.				Section A.	Section B.
6th day	..	..			G.
11th	..	..		M. & W. (1) —→	G.
12th	..	..			G.
13th	..	..			G.
24th	..	..	}	M. & W. (2) ↓ & G. ←	m. & c.
25th	..	..		G.	
30th	..	..		G.	
35th	..	..		G.	← M. & W. (1)
36th	..	..		G. ←	
37th	..	..		G.	
48th	..	..	}	m. & c. —→	M. & W. (2) ↓ & G.
49th	..	..			G.
54th	..	..			G.
59th	..	..		M. & W. (1) —→	G.
60th	..	..			G.
61st	..	..			G.

Key to Symbols.

Sections A and B represent duplicate section of the same experiment (see fig. 3).

M & W indicates that the herbage is mown and weighed.

G. indicates that the herbage is grazed and/or that mown herbage is eaten by sheep after being spread over the ground.

M & c indicates that the herbage is mown for clearing up growth to the same height as that under M & W in the adjoining section.

→ indicate that the mown herbage is transferred to

← the adjoining section and spread over the ground to be eaten by sheep.

↓ indicates that the mown herbage is spread over the plots from which it was cut to be eaten by sheep.

In the example given above, twelve-day periods between cuts have been taken. As was stated earlier, growth periods between cuts may range from ten days to two or three months according to the season of the year. Consequently times between cuts and between grazings will vary with the rapidity of the growth. Each of the grazings "G," which is indicated by a single day may be in reality more or less than a day depending upon the amount of herbage to be consumed and the number of sheep used. The number of grazings varies also according to the growth and weather conditions. During wet weather in the spring and summer it is found desirable to graze more frequently, utilizing the herbage at a shorter stage to prevent fouling. From 20 to 40 sheep are used for each grazing, giving a stocking rate of about 80 to 160 sheep per acre. No hard and fast rules so far as frequency and duration of each grazing are concerned can be laid down, for obvious reasons. As far as possible the sheep are brought off pasture similar to that under experiment. They should be kept on the trial area just long enough

to ensure good utilization of the herbage and not so long as to cause them to become hungry and to void more than the equivalent of the herbage eaten on the plots as this will result in in-brought fertility. If the sheep are hungry when put on the trial area and are taken off too soon before they have voided the equivalent of the herbage eaten on the plots removal of fertility will result. Both in-brought fertility and removal of fertility should be avoided in so far as reasonable judgment renders this possible. It is important that the "*m and c*" should take place immediately before or immediately after and on the same day as "*M. & W. (2)*" is carried out on the adjoining section. Fig. 4 is a general view of an experiment in which one section is at the "*M. & W. (1)*" stage and the other is being grazed. All herbage from the section being mown will be transferred to the section under grazing on completion of the cutting.

It will be noticed that the period between the last grazing of each section and the date of mowing for clearing up (*m. and c.*) is a fairly long one. In the example given it extends from the 13th to the 24th and from the 37th to 48th days for Sections B and A respectively. This last grazing is usually a severe one and the time elapsing between the grazing and the "*m. and c*" must be such that the more closely eaten herbage has time to recover to the height to which the mower cuts, namely, about one inch at least. If insufficient time is allowed, an error is introduced. This error occurred in the technique in the 1929-30 season referred to in Section 1 (c.) of this part. Its operation is shown diagrammatically in figure 5.

Explanation of Fig. 5. The diagonally shaded portions of "*a, b and c*" represent growing herbage. The unshaded troughs in "*a*" represent that portion of the herbage which, owing to being closely grazed, has not had time to recover to the level reached by the mower if the spelling period between the last grazing of a section and "*m. & c*" is too short. The growth "*b*" resulting from spelling for "*M. & W*" can be cut by the mower to stage "*C*" only. Consequently that portion represented by the unshaded troughs in "*a*" or the horizontal shading in "*d*" is not measured.

It is not impossible to alternate *one* mowing of each section with a grazing period immediately following the mowing of the other section, but if cutting is delayed by moist but good growing conditions the effective and rapid utilization of the herbage by stock may be rendered rather difficult, with the result that the period preceding *m. & c* may be too short to permit recovery of the closely eaten herbage to mower cutting levels.

(4) FERTILIZERS AND THE METHOD OF APPLICATION.

(a) *Sampling of fertilizers:*

Where fertilizers are under comparative trial sufficient of each fertilizer is obtained to cover the requirements for several years. The material is mixed and analyzed and in the case of highly soluble and hygroscopic fertilizers the moisture content is determined prior to each application. The quantity applied is then adjusted to give the correct amount of the fertilizing ingredient.

(b) *Method of application.*

The effective length of each plot for cutting and weighing is 30 ft. (See Section 6a below.) This represents the length which is dressed with fertilizers, the application being made with the assistance of the wind-shield shown in Fig. 6. The shield* is 7 ft. 6 in. long ($\frac{1}{4}$ length of dressed area in each plot) by 6 ft. in width, and enables the application of fertilizers to be carried out in spite of fairly strong wind, which would prevent the work being done without some such device. Each fertilizer is weighed out in $\frac{1}{4}$ -plot lots and mixed with a small quantity of sand to facilitate hand distribution. All plots receive the same amount of sand whether fertilizers are applied or not.

(5) THE MOWER AND GRASS CATCHER.

The mower illustrated in Figure 7 takes a 24-inch wide cut. The front roller has been removed and a longer spindle fitted to take the small wheels shown in the photograph. Each of

*I am indebted to Mr. W. V. Blewett of Imperial Chemical Industries, for suggesting the use of the frame. I understand from Mr. Blewett that a somewhat similar device is used at the Waite Research Institute, Australia.

these wheels is 2 inches in width and is constructed from the original rollers supplied with the machine. Having the wheels outside the track of the cutting cylinder enables longer grass to be cut cleaner than would be the case if the front roller as originally fitted was left in position.

The sides of the grass catcher have been built up, particularly at the end adjacent to the cutting cylinder in order to prevent side wind from interfering with the delivery of the grass into the catcher. Canvas sheets are placed inside the catcher, being hung on pins fastened to the front and sides of the catcher. Stiffeners of hoop iron are sewn into the canvas to keep it evenly spread over the floor of the catcher. The edge of the canvas nearest the cutting cylinder barely reaches to the edge of the catcher, to which a small canvas flap is attached. This flap folds over the edges of the box and canvas when the mower is in operation and prevents grass from passing under the edge of the canvas. As soon as a plot is cut the herbage is lifted out in the sheet, a second sheet is placed in the catcher and the cutting of the next plot proceeds while the contents of the first sheet are being emptied into the weighing receptacle.

Light galvanized iron boxes fitting closely into the catcher and easily removable are being tried at present. These are proving satisfactory. They will serve as weighing receptacles as well as grass catchers and obviate the necessity of transferring the herbage to a special weighing receptacle as long as the scale pan is large enough to accommodate them.

(6) THE CUTTING AND WEIGHING OF THE PLOTS.

(a) *Opening up preparatory to cutting of the actual plots:*

A cut is taken across both ends of all plots leaving "headlands" between the ends of the plot in one series and those in the next. This is done by running the mower alongside the pegs so that the end of the spindle carrying the front wheels just clears the pegs. The distance from the line of pegs to the edge of the mower cut is 6 in. and the width of the cut 24 in.; this gives a headland 2 ft. 6 in. in width at both ends of all plots. Since the total length of each plot is 35 feet the removal of 2 ft. 6 in. from each end leaves a 30 ft. effective length from which to cut the herbage for weighing and leaves all plots the same length.

If the mowing is an "*M. & W. (1)*" (see Section 3 b), in which case the herbage will be transferred to the adjoining section, the strip of grass along the line of pegs is cleaned with a hand mower. If the mowing is an "*M. & W. (2)*" clearing of this strip is not necessary.

(b) *Cutting the plots for weighing:*

Each plot is cut by taking the first cut about 8 inches inside the edge of the plot and the return cut so that the small front wheel overlaps the wheel mark of the first cut leaving about 8 inches of uncut sward ("discard") down the middle line of the plot. This ensures that only herbage not previously rolled down by the wheels of the mower is dealt with. Fig. 8 shows the cutting of the plots in operation. It will be noticed that discard strips about 16 inches wide between plots alternate with strips about 8 inches wide down the middle line of each plot.

If the mowing is an "*M. & W. (1)*" the discard strips are cleaned up after all weighing is completed (see Fig. 9) and the herbage transferred to the adjoining section. When the mowing is an "*M. & W. (2)*" the herbage after weighing is returned to the plots from which it was cut (see Fig. 8) and discard strips are left to be eaten by sheep, except on occasions when growth may have been excessive as a result of unfavourable weather delaying the cutting. In the latter case the discard strips may be mown to ensure good utilization by sheep, the herbage being returned to the ground as it is cut.

(c) *Weighing of the herbage:*

The weighing is carried out with the scales and under a wind shelter. The scales are of the ordinary knife-edge type and give accuracy to within 5 grm. for weights of three or four pounds. Their sensitiveness decreases as the weight used increases, but accuracy to within 10 grm. is obtained with weights up to 10 lb.

The weighing receptacles are exactly the same weight and are counterbalanced so that net weights are recorded direct.

(7) **SAMPLING OF HERBAGE FOR DETERMINATION OF DRY MATTER CONTENT AND/OR ANALYSIS, METHOD OF DETERMINING DRY MATTER, AND A DISCUSSION ON GREEN WEIGHTS VERSUS DRY MATTER WEIGHTS.**

(a) *Sampling:*

The herbage of each plot is sampled as soon as it is weighed by taking a good handful of herbage from the weighing receptacle and placing it in a bag marked with the treatment number. On completion of the weighing of all plots, each bag contains a composite of samples from six plots, if there are six replications of each treatment in the section cut. The total weight of each composite is about 1500 grm. Each composite is thoroughly mixed within itself and 500 grm. are weighed out. This is then forwarded to the Chemist for determination of dry matter content and chemical analysis, if the latter is desired.

The bags used for collecting the samples during cutting are of waterproof material. Doak (2. p. 65) found that loss of moisture by collecting in this way over a period of several hours was negligible.

(b) *Carrying out dry matter determinations:*

This work is carried out by Mr. B. W. Doak, Analytical Chemist, Plant Research Station. The 500 grm. samples are spread out in galvanized iron trays 18 in. × 12 in. × 13 in., and placed in a simple oven heated by a series of gas jets situated below a baffle plate in the bottom of the oven. Each oven has room for twenty trays. The temperature is maintained at about 45 to 50° C. for 36 to 48 hours (although most of the moisture which can be driven off at this temperature is removed in 24 hours) after which the moisture content of the herbage is about 4 to 5 per cent. The herbage is then ground in a G. and N. Laboratory mill and determination of the residual moisture is then made by drying at 100° C. in an electric drying oven.

(c) *Green versus dry matter weights of herbage:*

Generally speaking, the determination of yields in terms of dry matter is desirable for the following reasons:—(i) differences in height or density of growth influence the amount of external moisture which it is not always possible to eliminate; (ii) rapid growth induced by a fertilizer treatment frequently results in a lowering of the dry matter content; this is well exemplified in parts 2, 3 and 4 of Bulletin 31 (1); (iii) I think it is equally safe to state that in most cases rapidly growing species or rapidly growing strains of species have lower dry matter contents than less rapidly growing ones.

It is not always possible to make the herbage as dry as is desired for cutting and weighing, and the determination of dry matter eliminates much doubt. Where a comparison is being made between treatments or strains which do not differ markedly, a reasonably accurate measure of the relative merits of the respective treatments may be obtained from green weights. Where differences in yield or habit of growth are considerable, that treatment yielding the greatest bulk of green herbage is likely to be unduly favoured by a comparison of green weights only by virtue of the fact that not only is it certain to hold more external moisture, but it will probably have a higher moisture content in itself.

Although comparison between treatments on a dry matter basis may leave much to be desired in absence of metabolism work or ordinary feeding trials, it is undoubtedly more satisfactory than comparison of green weights.

(8) **RECORDS OF BOTANICAL COMPOSITION OF PASTURE.**

In addition to notes on the general appearance and relative production of different species which are made at each cutting, the experiments are examined by a skilled ecologist at intervals of a few months. This work is carried out by Mr. E. A. Madden, Assistant to the Agrostologist.

C.—AN OBJECTION TO THE TECHNIQUE OF ALTERNATE MOWING AND GRAZING AS PRACTISED AND AN ALTERNATIVE METHOD WHICH ELIMINATES THE OBJECTION.

(a) *The objection discussed:*

The chief objection to the system of alternate mowing and grazing as practised is that the more or less uniform distribution of animal excrement over the area of an experiment is likely to

result in the "transference of fertility" from the plots of the higher to those of lower yielding treatments. The objection seems to be perfectly valid if we consider an example of an experiment in which there are six treatments, five of which receive fertilizer and as a result yield 50 per cent more than the sixth or no fertilizer treatment. If all the animal manure resulting from the consumption of the herbage is evenly distributed over the area there must surely be a tendency after a year or two towards a levelling of production from all treatments. If, however, the time spent in the grazing of each plot is proportionate to its production and the return of animal manure to each plot is proportionate to the grazing, the transference of fertility would be *nil*. With plots of the size used, the latter occurrence seems unlikely for obvious reasons.

However, the results from an experiment in which each plot was only 4 ft. 3 in. in width suggest that the unlikely is happening to a very considerable extent, or that the transfer of animal manure is not a very disturbing factor in relation to the effect of an application of artificial fertilizer.

The experiment in question has been under the system of alternate mowing and grazing for three years and seven months up to the time of writing.

There are five treatments, each receiving the same amount of superphosphate in different ways, and a "No superphosphate" treatment. One of the superphosphate treatments receiving 4 cwt. every August, which has yielded at about the average of all super treatments, is chosen for comparison with "No super." The results in yields of pounds of green herbage per acre are given for each of three annual and one seven-monthly period. Results in terms of dry matter are not available for the whole period, but the relative results are not materially altered by using the yields of green material in this case.

Yields of Green Herbage Per Acre to Nearest 100 lb.

Season of 12 mo. approx.	No super.	Super at 4 cwt. per annum.	Difference.
1929-30	17,900	24,100	6,200
1930-31	27,700	43,800	16,100
1931-32	29,300	42,200	12,900
1932-33 (Seven months later).	35,400	51,300	15,900

The yields during the first season are low, partly because of the weakness in the technique referred to in section I.c., and partly because the pasture was not thriving particularly well. There is a marked increase in the yields of both treatments in the second season and in the increase due to the super application. In the third year a slight increase in the yield of the "No super" treatment and a slight decrease in that of the super occurred, the difference due to super being less than in the second year. This immediately suggests that the effect of transference of fertility is making itself felt. In the first seven months of the fourth season, which has been a very favourable one however, the yields of and differences between the two treatments are greater than they were during the previous twelve months. Further, on the average of the results of the previous seasons for the balance of the year, a conservative estimate indicates that the yields of "No super" and "super" respectively will be about 40,000 and 60,000 lb. giving an almost certain difference of at least 20,000 lb. in favour of super.

Just what the differences would have been had the treatments been completely isolated is a matter for conjecture, but it would appear that the effect of transference of fertility is not influencing the relative results from the two treatments cited to a great extent. In any case it is certain that the differences are likely to err on being conservative rather than exaggerated. In the investigation quoted the difference between "No super" and "super" is merely incidental to the main issue as to the effect of different methods of applying super. It has been possible to show that different methods of application do give different results, so that the point has been gained in spite of possible effect of transference of fertility.

- (b) *An alternative method of conducting the alternate mowing and grazing technique, to eliminate transference of fertility.*

In suggesting the modification to the alternate mowing and grazing technique, it must be understood that such modification has not been practised in New Zealand as yet. In the opinion of the writer, an attempt to obtain such increased refinement as would be brought about is not warranted at the moment with the problems under investigation, especially in view of the extra expense of fencing and the extra labour in cutting, and in manipulation of stock. However, the desirability of adopting the more refined technique, as problems of a different nature are attacked, is fully appreciated.

Fig. 10 illustrates a simple layout which would enable the system of alternate mowing and grazing to be practised without interference of one treatment with another. For simplification, such things as gates and races to facilitate movement of stock are omitted from the figure. The general principle is all that it is desired to illustrate here and two treatments only are included. The positions of auxiliary areas, too, could be modified as desired.

Each of the A and B series of plots can be taken to represent one of the sections as illustrated in Fig. 3, the main difference being that in this case each plot is isolated. The alternate mowing and grazing of two series could be carried out in the same general way as has been described in Section 3.b, except that in the present instance each plot would be stocked separately. The auxiliary areas would have the same treatment applied as that on the plots of corresponding number. Only one auxiliary area would be required for each treatment under trial; this area would be of a size such that sufficient sheep to graze all the plots of corresponding treatment could be grazed for two or three days prior to their being put on the actual plots for grazing or eating mown herbage. This would ensure that animal manure resulting from herbage of the same nature as that on the plots themselves was carried on to the plots. The control of herbage on the auxiliary areas would have to be similar to the control exercised on the plots, and if necessary could be carried out by, or with the aid of, stock other than those used for grazing the plots.

It is suggested that each individual plot should be at least half a chain square= $1/40$ acre. This would probably necessitate the use of from two to four sheep per plot at each grazing, depending on growth conditions. Each auxiliary area would require to be about twice as large as the total area occupied by all the plots of one series of the corresponding treatment. This would ensure sufficient grazing for the two or three days specified. Square, or nearly square plots or auxiliary areas would ensure more uniform grazing and lessen the tendency for stock to camp at ends or corners.

D.—THE TECHNIQUE OF STOCK GRAZING TRIALS.

Any pasture experiment which does not measure the whole of the production from all treatments concerned leaves much to be desired, as that portion which is left unmeasured may represent all or a portion of the total difference between the treatments under comparison. This applies irrespective of the means of measurement adopted. As an example of what is meant, consider a stock-grazing trial in which two treatments are being compared. Because of bad management or an error in estimating the stock required there may be a surplus of 10 per cent of unconsumed herbage on one treatment and 20 per cent on the other. The records may show equal carrying capacities for the two treatments, the very difference which it was desired to measure being represented in the unconsumed surplus.

Two types of grazing trials have been practised in New Zealand in recent years. One type may be designated the "Single-field" trial and the other embodies replicated fields with a special auxiliary area for each of the treatments.

- (a) *The single field trial:*

This consists of the division of as uniform a field as can be obtained into the desired number of equal parts or the sowing of equal areas, of similar previous history, in the treatments under comparison. Each of the areas is stocked intensively when it is considered to be at a suitable stage and then closed to permit recovery of growth. The same class of stock is used on all areas and comparisons made in terms of sheep- or cow-days, depending on the class of stock employed.

The large errors associated with this type of experiment make it suitable only for the comparison of treatments likely to show big differences and for trials in which only records of carrying capacities are required.

It has been employed by the N.Z. Department of Agriculture (3) for comparison of a basal manuring plus nitrogen with the basal manuring only, in a series of about 80 trials extending over two seasons.

It has also been employed in six centres in the South Island for the comparison of the carrying capacity of pastures sown with certified perennial ryegrass as the dominant species on the one hand, and with a mixture of commercial, so called, perennial ryegrasses as the dominant on the other hand. The results from this series of trials have been particularly gratifying up to date. Over a period of two years the superiority in the carrying capacity of the certified over the ordinary commercial ryegrass has been 34 per cent. The certified ryegrass is superior in all cases, the increases ranging from 8 to 93 per cent in the individual trials.

(b) *The replicated field plus auxiliary area trial:*

If the object of a grazing trial is to determine, in addition to the relative carrying capacities of the treatments under trial, the influence of the herbage produced on live weight increase, wool production (or milk production in the case of dairy cows) and the effect on lamb production, two main sources of error must be reduced as much as the desired degree of precision demands. The first source of error is that due to fertility variation in the soil, and the second that due to variation in the stock themselves. (It is assumed that ordinary precautions, such as the selection of the same class of pasture and stock, comparable times of grazing or stages of growth at which grazing takes place and comparable severity of grazing, etc., are observed.) Errors due to fertility variation can be reduced only by the replicating of the trial fields in a suitable way. The reduction in errors due to stock depends upon the number of stock used. Errors associated with stock feeding experiment have been dealt with very ably by Mitchell and Grindley. (4)

The type of trial under consideration is considered to make allowance for these major sources of error. Figure 10 (Part B) will serve to illustrate the general layout of such a trial, the actual trial fields being represented by the A series instead of both series of plots.

A sheep grazing trial of this nature was commenced at the Department's experimental farm at Marton in 1928. Two treatments were under trial, there being four replications of each. Each of the treatments had a single auxiliary area under the same treatment, the area of each auxiliary being equal to the total area of all the trial fields of the same treatment. It is not suggested that it is necessary to have an auxiliary area of this size, but it proved to be a convenient one in the trial mentioned.

In order to intensify the relative effects of the treatments on the general well-being of the sheep and their wool or fat lamb production, it is obviously desirable that the same sheep should be kept under trial for two or three years at least. Consequently young ewes should be selected.

A general outline of the procedure adopted when the object of the trial is to carry breeding ewes and raise their lambs to the weaning stage on the experiment is given below. A simple fattening trial would present fewer difficulties.

A flock of ewes which will be designated the "permanent flock" is allocated to each treatment. The number should be such that the permanent flock can be carried on the trial fields and their auxiliary areas at times of lowest production, thus ensuring that the sheep are on the same treatment throughout the duration of the trial.

The permanent flocks are grazed over their appropriate trial fields in rotation. During periods of lowest production they are grazed on the auxiliary areas while recovery of growth is taking place on the trial fields. During periods of high production the permanent flock is supplemented by "temporary" sheep either by adding them to the permanent flock or using them as "followers" in the grazing rotation. Periodic weighing of the permanent sheep is carried out and wool and lamb yields as well as the grazing hours are recorded. Grazing hours only are recorded so far as the temporary sheep are concerned. The auxiliary areas are kept under control by the use of the temporary or other "outside" sheep during high production periods.

From four to six replications of the trial fields of each treatment provide a suitable number for a good rotational grazing scheme. If this number of fields is insufficient to reduce errors due

to fertility variation to a satisfactorily low level, the number should be doubled and the flock allocated to each treatment divided into two lots instead of attempting to manage a single rotation of eight to twelve fields. A rotation of eight to twelve fields would be manageable during slow growth periods, but at times of rapid growth it would involve practically daily movement of stock in order to ensure that the resting period of each field was not so prolonged as to allow the herbage to pass beyond a stage where it could be efficiently utilized. The use of the larger number of replicates would be extremely advantageous if it was desired to imitate a "whole-farm" scheme of trial. The permanent flocks could be concentrated on some of their fields, while the remainder were closed during periods of high production for the conservation of hay or silage with which to feed the stock during periods of low production.

From two- to four-day grazing periods, according to the season of the year, involving eight to sixteen days' spelling in a 4-field-rotation have been found satisfactory under conditions of the trial at Marton, although during periods of low production the spelling periods have sometimes been longer when it was necessary to resort to the use of the auxiliary areas for grazing the permanent sheep.

From 20 to 50 sheep for each treatment, or more if a high degree of precision in the measurement of differences in meat, wool or lamb production is desired, are necessary for the permanent flock.

It is impossible to lay down hard and fast rules so far as rates of stocking and the duration and frequency of grazing of each field are concerned. Pasture, soil, climate and class of stock are all important in determining these factors and a system suited to one locality may be quite unsuited to another. Those who have attempted grazing trials under a system of rotational grazing with the efficient utilization of herbage at all times of the year will appreciate the difficulties and be fully aware of the manipulation of stock which is necessitated. In the trial at Marton over 20 sheep per acre were carried during one four-monthly period, while in the same year the carrying capacity dropped to 2 or 3 sheep per acre during a dry spell extending over about two months.

A general principle which should be borne in mind is that "the periods of spelling between grazings should be as long as possible commensurate with good utilization by the stock employed and the pasture should not be grazed too closely."

The method of "replicated-fields plus an auxiliary area" for grazing trials has also been advocated by Flay (5) as the best alternative to the "whole farm" trial.

E.—EXTENSION TRIALS AND DEMONSTRATIONS.

One of the great necessities of the agricultural research worker is a direct link with the farmer. Workers in research organizations whose activities are confined to their own institution are at a distinct disadvantage in that, while their research may be of a very high order and the results of general application, the farmer is inherently conservative to the point of doubting whether such findings are applicable to his own particular farm or district. In the absence therefore of some form of extension trials or demonstrations, much of the advantage of research may be lost or become very slowly absorbed into practice. Moreover, the research worker who does not come into contact with farmers' problems on their own farms is apt to fail in his appreciation of the problems directly confronting the farmer.

An outline of the organization of the Plant Research Station and the Fields Division, two branches of the Department of Agriculture, concerned, amongst other things, with research into and advice regarding farm crops including pastures, will assist in indicating the link between research and practice in New Zealand.

The Plant Research Station, as the name implies, is concerned primarily with research, and is comprised of a group of specialists under a Director. Some of the specialists are engaged in work intimately concerned with practice in the use of species or strains of pasture and other plants and the use of fertilizers. The trial or demonstration of the use of certain practices under varying conditions throughout the country becomes a matter of some importance; this is achieved by co-operation with the Fields Division, which is the advisory branch of the Depart-

ment of Agriculture so far as pastures and crops are concerned. The work of the Fields Division, under a Director, covers four main districts, each under a Superintendent. Each Superintendent's district is divided in five or six sub-districts, in each of which is at least one resident Instructor. In this way New Zealand is divided into 22 Instructorates; the officers in these instructorates carry out, in addition to their other duties, field experiments in co-operation with farmers or on such areas as are under the control of the Division.

When a specialist officer of the Plant Research Station wishes a certain investigation carried out in any or all of the instructorates, the project is discussed with the Director of the Fields Division and when the general form of the investigation meets with the approval of the officers concerned, the administration of it is handed over to the Field Crop Experiment section to be communicated to the Superintendent concerned. Alternatively, individual Instructors are at liberty and are encouraged to forward proposals regarding investigations which they may consider desirable in their respective districts.

The method to be adopted in any experiment is finally decided upon by the Field Crop Experiment Officer in collaboration with the Director of the Fields Division.

A systematic method of reporting and recording the results of experiments has been adopted. As soon as an experiment is laid down a "Laying Down" report embodying the necessary relevant data is furnished. Each experiment is visited for inspection at intervals of from one to three or four months, depending upon the nature of the experiment, and "Progress" reports are made out. This continues while the experiment is being carried on. Each report is made out in quadruplicate. One copy is retained by the officer carrying out the experiment and one is forwarded to the co-operating farmer, the Fields Superintendent and the Experiment Section of the Plant Research Station respectively.

As soon as a "laying down" report is received by the Experiments section, a special file is made out and an "Experiment Number" allocated, the Fields Superintendent and the Instructor concerned being advised. The allocation of the experiment number ensures uniformity in future reference to any experiment and obviates any tendency to confusion.

The whole system ensures the promulgation of any particular project or policy and obviates the danger of losing sight of work being carried out by any officer if that officer is transferred or leaves the service. The work of filing and "bringing up" of files for the inspection of the specialist at specified times to ensure that no experiment is lost sight of at the Headquarters of the Experiments section is carried out by a clerical officer. At the present time about 600 experiments are being carried out under the above system. Examples of some of these will suffice to indicate the nature of this extension work.

The grazing trials referred to in Part D. were carried out under the system described. Numerous trials of an observational nature of different types or strains of grasses and clovers are being conducted on behalf of the Agrostologist. A certain strain of rye-grass or clover may have proved superior to other strains at Palmerston North. To what extent this superiority is due to soil and climate is a point which it is necessary to determine. The institution of a series of trials in various parts of the country enables this to be done under conditions of varying soil and climate. The greater persistence and superior production after the first year of the type of perennial rye-grass being certified, over all others, irrespective of soil and climate is a case in point where the extension trials have proved invaluable.

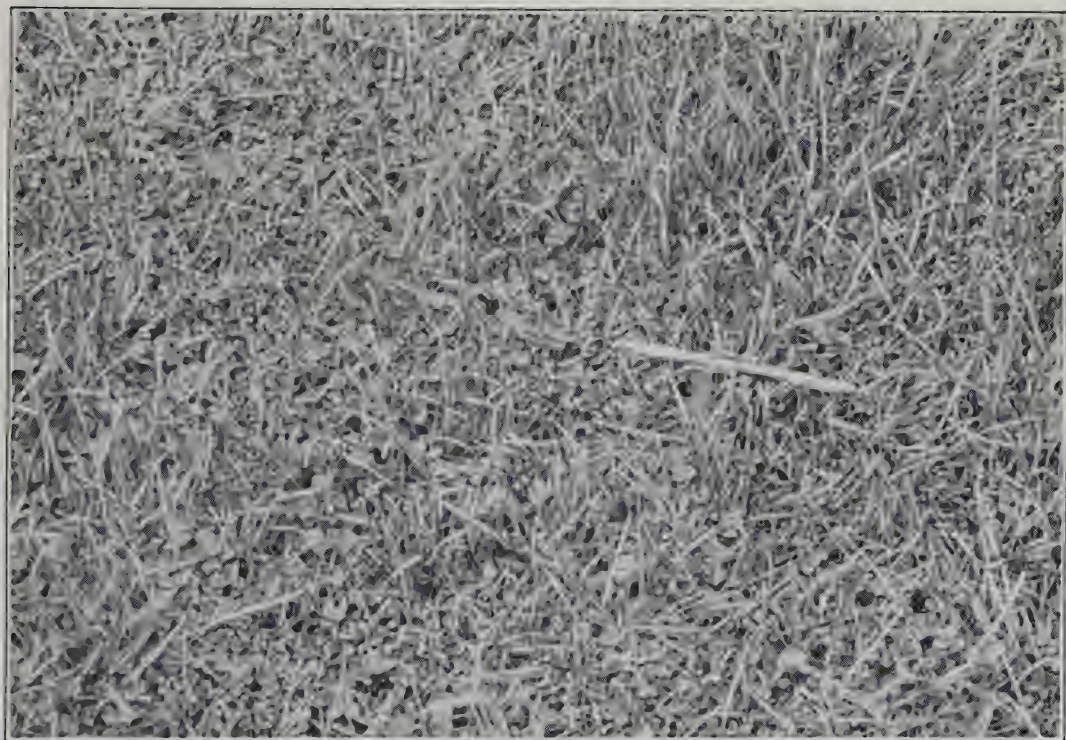
On the fertilizer side a series of simple experiments is being conducted in order to constitute a "response-to-manure" survey in New Zealand. Lime, phosphate, potash and nitrogen alone and in various combinations are being tried in as many places as possible and the responses as indicated by observation recorded. Experiments of this kind may leave much to be desired, but in a good proportion of the trials the results are so definitely positive or negative as to leave no doubt regarding the economic value of the treatment applied. Thus farmers are readily provided with information on their own land regarding what they should use, or at least try, on a larger scale.

In "observational" experiments of the kind instanced above the individual plot is usually quite small, ranging from $1/5 \times 1/4$ chain ($1/200$ acre) to $1/5 \times 1$ chain ($1/50$ acre). Plots of such a size are quite as effective for observing the behaviour of a strain of pasture plant or a



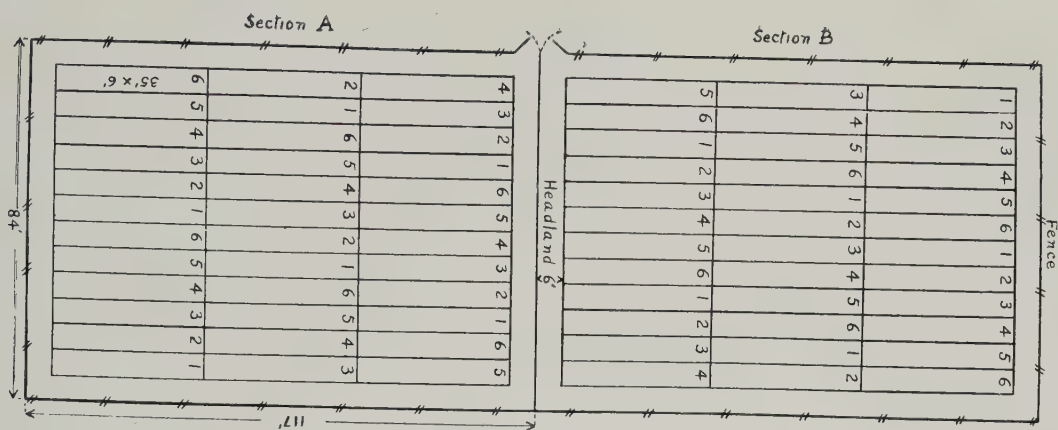
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FIG. 1.



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FIG. 2.



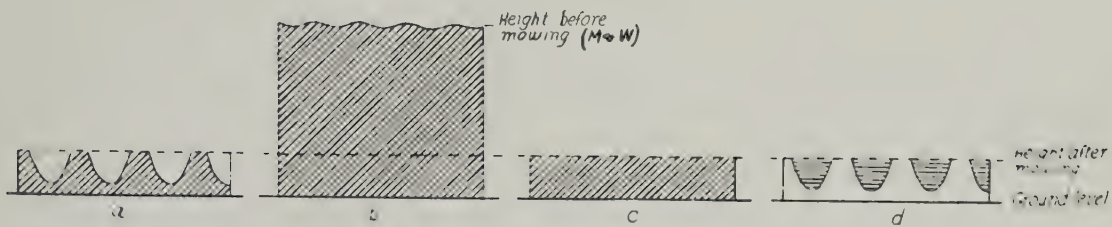
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FIG. 3.



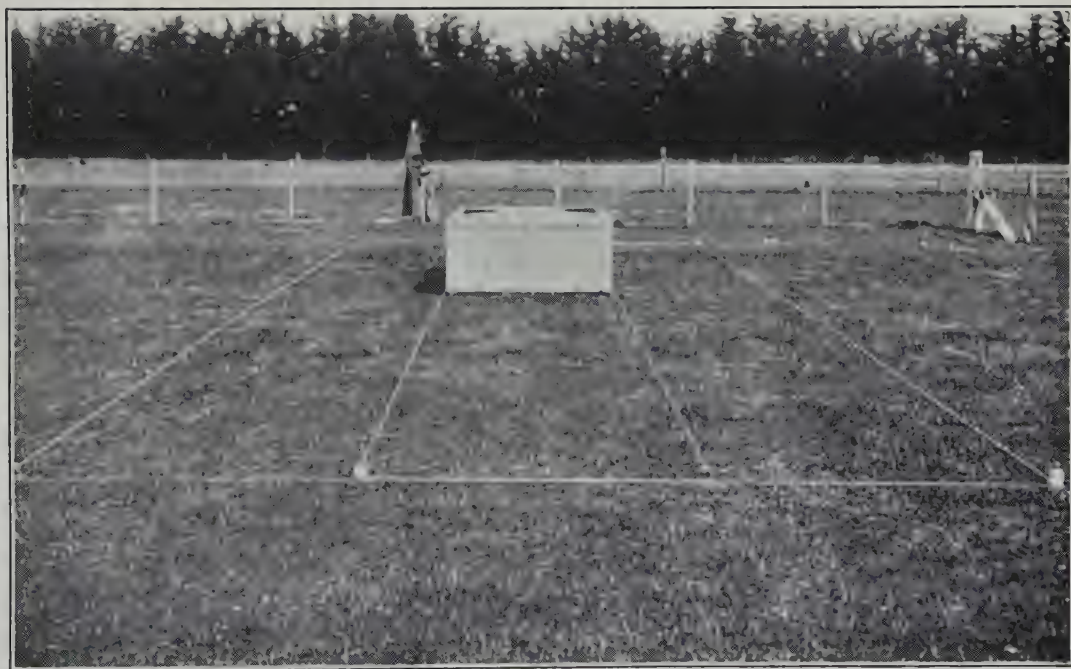
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FIG. 4.



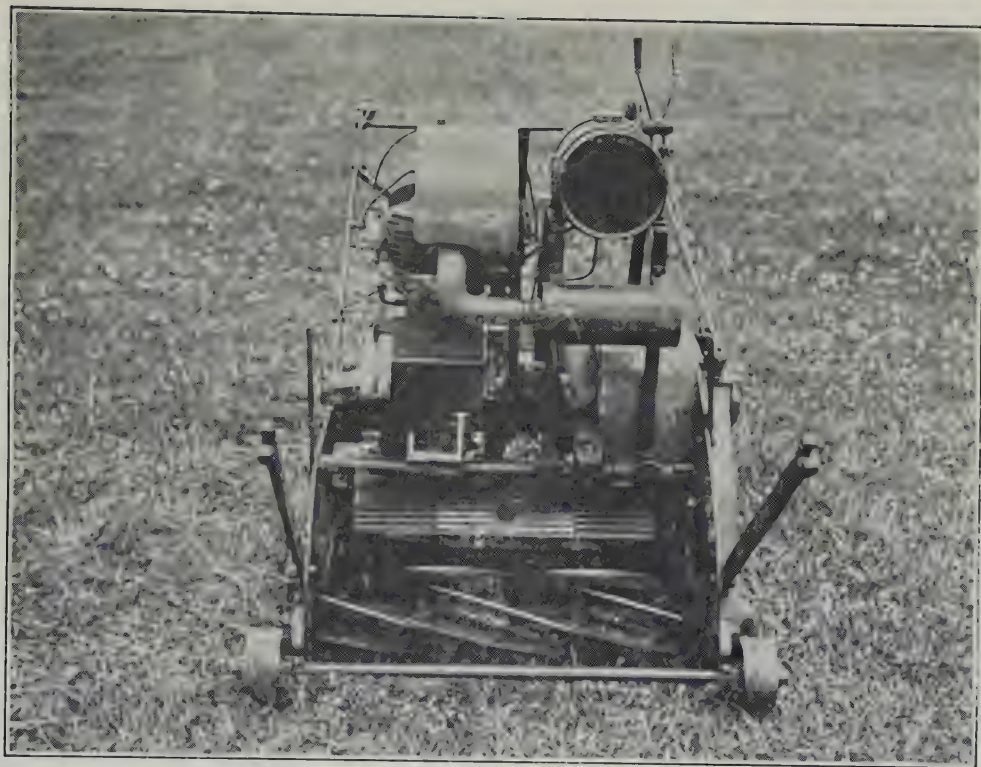
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FIG. 5.



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FIG. 6.



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FIG. 7.



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FIG. 8.



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FIG. 9.

<i>B Series</i>	1	2	2	1	1	2
<i>A Series</i>	1	2	2	1	1	2

x Replications

<i>Auxiliary to 1</i>	<i>Auxiliary to 2</i>
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FIG. 10.

fertilizer as larger plots and have the added advantage of requiring only a small expenditure in material and labour. Further, the small area occupied by each trial permits the more easy selection of uniform ground or sward. As often as not such experiments serve as much for demonstration as for investigation and the greater number which can be laid down by virtue of their cheapness adds materially to their value from point of view of demonstration to farmers on their own particular class of country.

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TITLES TO ILLUSTRATIONS.

- FIG. 1.—This sward, which consisted of a good mixture of perennial ryegrass and white clover five months prior to the photo being taken, was subjected to mowing only (eleven cuts) with the removal of herbage. Note the growth form of the Catsear and Ribgrass plants on the left and right respectively and the small production from ryegrass. Compare with Fig. 2. Photo by H. DRAKE.
- FIG. 2.—This is portion of the same pasture as that shown in Fig. 1. It was under alternate mowing and grazing with the feeding back of mown herbage for the same time that the sward in Fig. 1 was under mowing only. It went through five mowing and five grazing periods during the five months. Note the greater vigour of the ryegrass and the growth form of the Catsear plant which has been eaten by sheep at the point of the pencil. Compare with Fig. 1. Photo by H. DRAKE.
- FIG. 3.—Plan of a typical experiment under the alternate mowing and grazing technique. (See Pt. B., Sects. 2 and 3 for discussion.)
- FIG. 4.—A general view of an experiment under the alternate mowing and grazing technique. The section in the foreground is at the "M. & W. (1)" stage (see Pt. B., Sect. 3b). That in the background is being grazed. All the herbage from the section in the foreground is cut and transferred to the other section to be consumed by sheep on completion of the weighing of the strips cut from the plots. Photo by H. DRAKE.
- FIG. 5.—Diagrammatic representation of the introduction of an error in the measurement of production if the spelling period prior to "m & c" (see Sect. 3b) is too short. (See explanation in text.)
- FIG. 6.—Wind shield used when applying fertilizers to individual plots. The ends of the shield are about 1½ in. clear of the ground and the ends of the side runners are rounded so that the contrivance can be "sledged" easily from one position to the next. Photo by H. DRAKE.
- FIG. 7.—The 24 in. motor mower used for cutting. (See Sect. 5 for discussion on modification to front roller.) Photo by H. DRAKE.
- FIG. 8.—Cutting strips from plots for weighing. (See Sect. 6b for discussion.) Photo by H. DRAKE.
- FIG. 9.—Cutting out discard strips when the mowing is an "M. & W (1)" (See Sects. 6b and 3b for discussion.) Photo by H. DRAKE.
- FIG. 10.—A simple layout to enable the system of alternate mowing and grazing to be practised so as to preclude the possibility of transference of fertility. (See Pt. C (b). for discussion.)

4.—METHODS EMPLOYED IN THE BREEDING OF PASTURE PLANTS.

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In 1923 a very modest start was made on the selection of *Dactylis glomerata* and *Lolium perenne*—the two most important grasses in the arable lands of Canterbury. In both species great polymorphy was shown to exist. In 1927, with the assistance of a Government grant, a start was made with selection in *Trifolium pratense* and in 1930 work commenced on *Lolium italicum* and *Danthonia*.

In describing our methods, acknowledgment is made for the assistance we have obtained from the Welsh Plant Breeding Station at Aberystwyth. Dr. O. H. Frankel in 1929 was given details of the methods by the different workers and the information published by the Station has been a valuable guide.

SELECTION.

Material for selection has been collected from old pastures on different soil types from many parts of the South Island. Single plants are taken from grazed fields, and planted in the garden until large enough to break up for the formation of clone rows. While in clone rows the selections are grazed by sheep over a period of from 2 - 3 years, at the end of which time the best types are chosen for breeding. In most cases the selection plots are located on a farm in the particular district whence the plants were collected, but the selected plants are forwarded to the College plots for breeding.

SHELTER-POLLINATION.

In April, 1924, small clones of several types were planted at 5-chain intervals within a field of oats. Algerian oats, when sown in March will shoot before November 1st, so that at the time of flowering in the grasses the oats were 18 inches or 2 feet taller than the grass heads. Each clone is practically in a well of oats screened from drifting pollen to a considerable degree. Seed produced under these circumstances is called "Shelter-pollinated" seed.

That this is a fairly reliable method of self-pollination when applied to plants which are to some extent self-fertile will be seen from a study of the following tables.

Table 1.—Showing differences between seedlings of two different shelter-pollinated plants—*Lolium perenne*.

	Plant C2.	Plant C15.	Difference.
Number of flowering stems per plant on 23rd November in first year ..	30.7 $\pm$ 1.66	43.4 $\pm$ 2.38	12.7 $\pm$ 2.86
Angle of flowering stems to the horizontal (in degrees)	44.8 $\pm$ 1.01	79.0 $\pm$ 0.66	34.2 $\pm$ 1.17
Length to top cauline leaf (in cm.) ..	20.5 $\pm$ 0.25	17.4 $\pm$ 0.27	3.1 $\pm$ 0.37
Width of top cauline leaf at 1 in. from base (in mm.)	7.20 $\pm$ 0.08	6.26 $\pm$ 0.07	0.94 $\pm$ 0.1

It will be seen that C 2 shelter-pollinated seed produced plants that were significantly fewer-flowered (or later-flowered), more spreading, longer-leaved, and wider-leaved than the plants similarly produced from C 15.

Table 2.—Showing that offspring by shelter pollination resemble parents—*Lolium perenne*.

					Angle of the flowering stems to the ground (in degrees)	
					C.2	C5.
Parent	..	..	..	..	52.5 ± 1.2	75.0 ± 0.9
Offspring	..	..	..	..	44.8 ± 1.01	75.9 ± 0.8

Table 3.—Showing relation between shelter-pollinated, self-pollinated, and open-pollinated offspring in regard to length and breadth of leaf and comparison with the parent—*Dactylis glomerata*.

Length of 3rd top stem leaf in inches.				
Parent.		Offspring.		
		Shelter.	Self.	Open.
C4.	13.7	12.6	12.5	11.6
C13.	11.1	—	11.3	13.4
C23.	11.2	12.9	13.2	16.1
C45.	10.4	12.0	6.3	10.3

Parent.		Breadth of 3rd top stem leaf in mm.		
		Offspring.		
		Shelter.	Self.	Open.
C4.	8.4	8.0	8.0	8.1
C13.	9.4	—	9.6	11.3
C23.	8.6	8.2	8.1	9.9
C45.	10.1	9.7	8.3	9.2

Tables 2 and 3 show that in most cases there is a marked similarity between the self- and shelter-pollinated offspring for the characters noted, except in the case of C 45. The open-pollinated offspring show wider variation from the parent plant than do the shelter and self-pollinated offspring. This is very conspicuous in the growth forms of the families. Shelter-pollination is therefore being used to a considerable degree in the breeding of ryegrass and cocksfoot. Self-pollination by enclosing heads in parchment paper balloons is used for critical work.

REDUCTION OF VIGOUR ON SELFING.

The loss of vigour which occurs in the F₁ generation from selfing of cocksfoot is illustrated by the following experiment. Two parents and their self-pollinated offspring were broken up into tillers of equal size and planted out as spaced plants—chess-board fashion—twenty tillers of the parent plant and twenty tillers of each offspring. These were cut and weighed green at regular growth intervals; the results are given in the following table:—

Table 4.—Showing the mean weight in grams of the parent plant and the mean weight of a number of self-pollinated offspring—*Dactylis glomerata*.

Parent.	Offspring.								
C23. Weight :—571 grm.	1. 576.	2. 474.	3. 374.	4. 485.	5. 469.	6. 444.	7. 519.	8. 502.	9. 455.
	Mean weight of 9 offspring of C23=489 grm.								
C13. Weight :—638 grm.	1. 429.	2. 630.	3. 553.	4. 534.					
	Mean weight of 4 offspring of C13=536 grm.								

OFFSPRING TESTS AND STRAIN BUILDING OF SHELTER-POLLINATED PLANTS.

Shelter-pollinated seeds obtained from all the plants chosen from the selection plots are sown in sterilized soil in boxes in the glasshouse; the young plants are planted out in families of 60 - 100 single plants in the spring. Autumn planting has been discontinued owing to the losses caused by the grass grub (*Odontria zealandica*) during the first winter. Every 3rd plot is a control plot and consists of a good commercial line—the same line being used every year. These plots are grazed over a period of 2 - 3 years and the parents producing the best families are chosen for propagation. From a study of these offspring plots some definite information is now available regarding the hereditary make-up of the selected plants. If the selected parent is sufficiently homozygous it may be propagated vegetatively until sufficient material is available to plant an acre or more. An acre of one strain has been planted out in this way and seed has been harvested for three years. Field trials involving sheep grazing have been established, with promising results to date.

CROSS-POLLINATION.

Parent plants which have survived the shelter-pollinated offspring test but which show signs of reduced vigour are crossed in as many combinations as possible. The crossing is done by planting the parents alongside each other during the winter; when in flower the panicles are enclosed together within parchment paper balloons. At the same time panicles of the individual parents are self-pollinated in a similar way. The different amounts of seed obtained from the self-pollinated and cross-pollinated panicles afford some measure of the amount of cross-pollination which has taken place.

OFFSPRING TESTS AND STRAIN BUILDING OF CROSS-POLLINATED PLANTS.

Offspring of the cross-pollinated plants are grown as single plants in offspring plots alongside the self-pollinated offspring so that the effects of crossing can be further distinguished. The parents which combine to produce the best offspring are selected from a study of these families. They are then propagated vegetatively and planted out together in a sheltered field. Two strains of ryegrass and one strain of cocksfoot built up in this way have been harvested for the first time in the season 1932-33.

SELECTION AND BREEDING OF RED CLOVER.

The methods adopted for the selection and breeding of New Zealand red clover (*Trifolium pratense*) are based on the same principles as apply to cocksfoot and ryegrass, but the breeding is modified on account of the high degree of self-sterility and by the fact that pollination is brought about by bumble bees. The selection of plants consists in digging up plants from old pastures. Under Canterbury conditions red clover dies out after 3 - 6 years so that the oldest pasture in which we are able to find plants is only 5 or 6 years old. Where there has been a chance of re-seeding we select the old plants on the basis of a study of the root systems. We can with a fair degree of accuracy distinguish a plant over three years old from a younger one, but we are unable to distinguish definitely a three-year old plant from a six-year old plant. Anatomical studies of the roots were attempted, but they proved of negative value as a root dies when it is about three years old and the plant develops new tap roots. Thus the presence of an old rotted root stump with other tap roots of aged appearance points to its being an old plant with the capacity to establish new roots; such plants are chosen, while plants up to 3 years old can be definitely rejected.

These old plants are broken up into 2 or 3-plant clones and are under observation for 18 months to 2 years, during which time they are grazed by sheep. The best plants are then chosen for breeding.

BREEDING.

Selected plants are planted together in the winter and before flowering commences are covered with mosquito netting cages. Bumble bees are used to effect the crossing and are prepared according to the methods reported in Bulletin Series H, No. 4, of Welsh Plant Breeding Station, Aberystwyth.

OFFSPRING TESTS AND STRAIN BUILDING.

The seeds from these crosses are sown in sterilized soil in boxes and the resulting plants set out in early autumn as spaced plants in families of 40-50 plants, with every 4th plot as a control. The parents producing the best families, i.e., the most consistent and highest producers under the grazing conditions, are propagated by cuttings and planted out together for seed production isolated as far as possible from other red clovers.

DANTHONIA.

Two species of *Danthonia*—*D. pilosa* and *D. semiannularis*—are important pasture plants on poor permanent grasslands in both Islands. A collection of types from many parts of New Zealand has been made and both species exhibit an extensive variety of forms. There is some evidence of the presence of well-defined ecotypes, e.g., the forms from hot, dry, clayey formations are narrower leaved, more tufted, paler and earlier than the forms from warm, moist, volcanic soils, and so on.

Many plants are self-fertile, others self- and cross-sterile, and there are intermediate conditions. Owing to the self-fertility of many forms, breeding by selection is comparatively simple. Pure breeding lines can be established as soon as a self-fertile desirable type is found.

Self-fertilization is performed by enclosing panicles in parchment paper envelopes. In most cases the offspring are uniform and the method used, therefore, is to select individuals, self-pollinate them, and test their offspring.

5.—STRAIN TRIALS WITH CRESTED DOGSTAIL (*CYNOSURUS CRISTATUS*).

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Massey Agricultural College (University of New Zealand), Palmerston North.

The work on crested dogstail was commenced in 1929 with a view to determining its value and capabilities as a pasture plant. A commencement was made with single plants collected from permanent pastures on the College farm. The high rate of mortality of these suggested a lack of true persistency in this plant and, in order to determine to what extent re-seeding was responsible for permanence, the following trial was laid down.

(a) In the autumn of 1929 and spring of 1930 a series of 312 plots each $1/500$ acre in area was laid down to test the persistency under three different treatments, i.e., hay, three-weekly mowing, and weekly mowing, the two latter being to simulate rotational and close grazing respectively. The hay treatment was as for the weekly mowing, except that the hay sections of each plot were closed early in October and the hay cut at the maximum flowering date at the latter end of December. The plots measured 6.66 links by 30 links and were delineated by timothy (*Phleum pratense*) drills, the timothy seed being sown with the Planet Junior at the time of sowing of the plots. The seeding rate of the dogstail was at 20 lb. per acre; the trials represented the full range of New Zealand commercial seed samples and were duplicated when sufficient seed was available. The plots were placed with their longest axes at right angles to the direction of mowing and the portion allocated for each treatment also indicated by timothy drills. Only one manurial dressing was given each year, in the form of 2 cwt. per acre of ammoniated superphosphate (1 cwt. sulphate of ammonia and 2 cwt. of superphosphate) applied before closing the sub-plots for hay. No stock grazed the plots and no weights were taken of the cuttings removed, as only persistency figures were required.

The original soil germination of the seed was determined and subsequent counts of surviving plants were made annually with the aid of a wooden frame 5 by 14 in. carrying wires stretched across to give an internal area of 3 by 12 in., in which the counts were made. Five random counts were taken on each sub-plot (i.e. hay, three-weekly, and weekly mown sections) to determine the mortality rate of the plants under each treatment, and the figures were compared statistically. The survivors in 1932 were planted out as single plants, spaced out 15 × 8 in. apart, for observation, selection and comparison with a plant of known value.

(b) A study of spaced plants under arable conditions has been maintained throughout to determine the relative values of the different types of plant under observation. Seeds were sown in boxes kept either in the green-house or in a sheltered place during winter and planted out into the plots in September. The flowering dates have been noted and attempts made to correlate these with the number of barren and fertile tillers, flowering head density, withering of the leaf after flowering, persistency and general value. The plants selected from these have been subjected to periodic close cutting and notes on recovery rate obtained, while the best plant of these selections has been used as a standard for classifying all future selections.

(c) In order to compare the relative productivity of commercial lines with roadside and old permanent pasture plants, seeds were collected and sown direct into rows 2 rods long and eighteen inches apart. Every other row was grown from hand-collected seed and alternate rows were commercial lines. The produce has been cut periodically and weighed green, and flowering dates and other features noted on single plants of the same strains. There are thirty commercial and thirty hand-collected lines.

None of the plants under the above schemes has been allowed to produce seed while under trial and any increase in numbers has been made through clones.

(d) The agricultural value of the differently coloured "seeds" has been determined by constructing a chart of the main range of colours found, and grading seeds from different plants according to this standard. Seed heads were selected for uniformity in flowering date (the re-

mainder were cut off) and one head from each was removed to the laboratory at three-day intervals for examination when seed formation had commenced. It was thus possible to obtain the full range of "seed" colour from any one plant and the rate at which colouring took place. The colour determinations were carried out only in diffused daylight using a white background and a $\times 12$ binocular. Colour ranges were judged from the lower $\frac{2}{3}$ of the flowering glume; it was found possible to place the different coloured "seeds" into twenty colour groups.

These different groups were tested for interim and final germination counts under standard conditions and the grain weight per 200 grains obtained. Vitality was determined from the interim counts. There was a definite correlation between seed colour, seed weight, vitality and final germination counts, as reported.

(e) An attempt to segregate plants of several distinct types for seed production purposes was made in small plots in a field of spring sown Algerian oats. The plots were sixty feet apart arranged in a row, at right angles to the prevailing wind. The seed harvested has not yet been tested for uniformity.

No genetical work has yet been attempted and will not be commenced until more and better plants have been isolated by selection. Owing to the uniformly low persistency values of the commercial lots and their lack of productiveness after the first harvest year, improvement will of necessity be either from imported permanent pasture strains or from single plant selections. As yet only four imported samples have been under trial, but it is hoped to include further imported lines in the future.

6.—LUCERNE STRAIN TRIALS.

J. W. HADFIELD.

Agronomist, Plant Research Station.

Work commenced in September, 1930, the objective being the study of lucerne, more particularly the "Marlborough" (N. Z.) strain, to determine whether it offered any scope for improvement that might be of economic value.

Seed samples were obtained from overseas and from well-established stands in Marlborough, and several thousand of these seedlings were transplanted 30 × 30 in. to permit of individual plant studies. Records were kept of the performance of each plant and in January, 1932, about 300 of the most promising were selfed. To permit of a further and a more satisfactory study of the selected parents, cuttings were taken prior to selfing, and the clones thus raised have remained under observation till March, 1933.

The L₁ seed resulting from the selfing of the selected mother plants was sown in April, i.e., the autumn immediately following harvest. By September in the following spring the seedlings were large enough to be transplanted to their permanent quarters 30 × 30 in. apart. Late autumn sowing, although unusual, effects a saving of about three months and permits the plants to attain full growth, flower, and, if necessary, produce seed during the first summer. The parent was also transplanted alongside its progeny, an arrangement which has proved very convenient, permitting a direct comparison between parent and progeny.

We have now growing about 250 parents surrounded by their L₁ families and in another block the clones raised from the parents of these families.

The degree of variation manifested by the single plant studies indicated a promising field for selection. Moreover, the L₁ progenies have attained a very high degree of uniformity; in fact many of them appear sufficiently homozygous for practical breeding purposes. The L₂ families, of which we have a few, have attained an even higher degree of uniformity, rendering it very difficult to distinguish between the individuals in any one family.

Variation in yield, form and habit between the different families is nearly as great as that exhibited by the parents, and, the possibility of improvement having been demonstrated, more definite objectives now in view are:—

1. the selection of a superior hay type;
2. the selection of a hay and grazing type for dry conditions.

It is intended therefore to self the best plants in the best L₁ families. Present indications are that it will not be necessary to proceed to L₃; in any case, the restoration of vigour by the crossing of the best L₂ plants will be undertaken. Meanwhile the clones representative of the parents of the best L₁ families will be seeded during 1933/34 and tested against commercial Marlborough lucerne to determine whether any progress has been attained in the initial selection.

Problems such as pollination which have a direct bearing on technique in selection and commercial seed production are being investigated, but most of the results are as yet inconclusive



PAPER No. 6 [J. W. Hadfield]

FIG. 1. SELFING LUCERNE PLANTS.

7.—QUANTITATIVE HCN DETERMINATIONS OF WHITE CLOVER TYPES.

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Type determination of white clover (*Trifolium repens*) in connection with the certification scheme in operation in New Zealand is at present based on plot trial and eye observation over a period of at least twelve months from date of sowing. Outstanding types appear early in these trials, but it requires a full year to determine border line cases with a sufficient degree of accuracy, more particularly between the Mother seed class and the Permanent Pasture class, and between Permanent Pasture and Reject class. Work by Pethybridge, Ware, Sampson, Adams, and Findlay, using the picrate test, has demonstrated that variation in hydrocyanic acid content of white clover existed; the applications of this knowledge to type has clearly shown that there is a marked correlation between type in white clover and HCN content of the herbage. The material used in the HCN determinations made to date is from the row plots laid down by the Agrostologist in connection with eye-determination of type; the HCN test here described may be regarded as a material aid in the easy diagnosis of those types that are difficult to determine by eye at an early stage of growth. The method also serves to confirm eye determination of the more outstanding types at an early date. The technique adopted in carrying out the HCN test of the herbage is as follows.

The herbage is plucked at random from a number of places on the plot. The material so collected consists of leaf-blade and petiole, and is thoroughly mixed. Samples are kept for dry weight. A sample of 100 gm. is weighed out immediately, cut up finely, and transferred to a flask. About 200 ml. of distilled water are added, and the flask tightly stoppered. The flask is kept for 36-48 hours at a temperature of 35° C., after which the hydrocyanic acid liberated is steam-distilled and collected, either in saturated sodium bicarbonate solution and determined by titration with N/50 solution, or in standard silver nitrate solution. In the latter case the precipitate formed is filtered off by means of a Gooch crucible, and the excess of silver nitrate determined by means of ammonium thiocyanate solution.

About 300 samples have been analysed in this way. The approximate range of percentages of hydrocyanic acid for the various types is shown below :—

Strains of <i>Trifolium repens</i> .	No. of samples.	Percentage HCN in green herbage.
N.Z. Mother seed	97	0.0070—0.0130
N.Z. Permanent Pasture	110	0.0030—0.0070
Kentish Wild White	8	0.0035—0.0055
N.Z. Ordinary { Reject for	88	0.0010—0.0035
N.Z. Dutch { Certification		
Ladino	2	0.0007—0.0009
Dutch	10	0.0005—0.0006

There is a certain amount of overlap between the classes, especially between the Reject class and the Permanent Pasture class. This appears to be inevitable owing to the difficulty of determining accurately by eye into which class border line cases should be placed.

8.—THE USE OF SCREENED ULTRA-VIOLET LIGHT IN RYEGRASS TYPE DETERMINATION.

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Seed Analyst, Plant Research Station.

Since Gentner observed in 1929 that a fluorescent condition was produced along the line of contact when seedlings of *Lolium multiflorum* Lam. were grown on absorbent paper, and examined in ultra-violet light, much progress has been made in the application of the phenomena to the diagnosis of perenniality in the genus *Lolium*.

Gentner reported that the seedlings of *L. multiflorum* invariably showed a positive reaction, while of those of *L. perenne* a proportion was positive and a proportion negative. Later work by Linehan and Mercer demonstrated that the presence of fluorescent individuals in perennial ryegrass indicated hybridization with *L. multiflorum* and suggested that the test applied as a percentage positive reaction might be used as a measure of the degree of perenniality of any line under examination, and therefore that the ultra-violet test could possibly be used as a laboratory method to distinguish between valuable and inferior strains of perennial ryegrass.

At this period, work designed to correlate the ultra-violet light reaction with plant type as determined by plot trial was planned by the writer, an examination of over 500 samples representing lines of known classification being made. The results of this work were published in December, 1931, and the following extracts and comments may be regarded as a summary:

Table I.—Grouping, according to percentage of fluorescent seedlings, of samples previously classified on plot trial.

Group.	Range percentage of fluorescent seedlings.	Plant-type No. 1.		Plant-type No. 3.		Plant-type No. 4.		Class.
		Number of samples.	Percent-age of samples.	Number of samples.	Percent-age of samples.	Number of samples.	Percent-age of samples.	
	Totals ..	232	..	92	..	56	..	..
	Up to 3	163	70	..	..	..	..	} Type No. 1.
I.	Up to 5	217	93	15	16	..	..	
II.	6 to 10 ..	15	7	33	36	2	4	} Type No. 3.
III.	11 to 20 ..	..	..	32	35	7	12	
IV.	21 to 30 ..	..	..	9	10	4	8	} Type No. 4.
V.	31 to 60 ..	..	..	3	3	11	20	
VI.	61 to 90 ..	..	..	..	..	19	34	
VII.	Over 90	..	..	..	..	13	22	Type No. 5.

In table I the total samples examined are grouped according to the percentage fluorescence exhibited under type headings as determined by plot trial. The type classification shown at the right is that suggested as being applicable to the various percentages and will be seen to agree closely with the plot classification.

It will be observed that of the total number of samples originally classified type 1, 93 per cent showed test percentages of not more than 5 per cent, the remaining 7 per cent showing between 6 and 10 per cent. Of the type 3 lots, 33 per cent gave percentages between 6 and 10, and 35 per cent between 11 and 20, and of the remainder 16 per cent showed not more than 5 per cent. From these and other data a classification based on the percentage fluorescent seedlings was proposed as follows:—

Type 1: not more than 5 per cent + seedlings.

Type 3 { 3a 6 to 10 per cent „
 3b 11 to 15 per cent „
 3c 16 to 20 per cent „

Type 4 { 4a 21 to 30 per cent „
 4b 31 to 50 per cent „
 4c 51 to 80 per cent „

a=better than average. b=average. c=below average.

Type 5: more than 80 per cent + seedlings.

The slight discrepancy between the plot and lamp classification was considered to be due possibly to small chance errors in the lamp testing or to soil differences, etc., in the plots. The conclusions then drawn from the study may be presented in full.

“ At the present juncture it is difficult to offer any definite explanation as to the causes underlying the appearance in a group of a more or less fixed percentage of plants carrying the factor or factors for fluorescence, and to the relationship between that percentage and the plant-type representative of the group.

“ To obtain data as to the exact nature of positive and negative reacting material in the various classes, some five thousand seedlings have been removed from the test pads and planted out for examination. Pending the result of these examinations, it is perhaps of interest to review briefly hypotheses which could account for the behaviour under the quartz lamp of the various classes of hybrid perennial.

“ It must be accepted that—

- (a) genetically pure perennial ryegrass does not exhibit fluorescence, or is always negative ;
- (b) genetically pure Italian ryegrass does exhibit fluorescence, or is always positive ;
- (c) the hybrid individual may or may not exhibit fluorescence ;
- (d) for each of the classes of ryegrass, there is a more or less definite proportion in which the positive and negative reacting individuals occur ;
- (e) the proportion of fluorescent individuals is smallest in the most persistent class and greatest in the least persistent class ; there is a distinct negative correlation between the proportion of fluorescent individuals characteristic of the class and the degree of persistency.

“ The points to be determined are :—

- (a) of the plants bearing the factors for fluorescence, what type of individual is represented by the 5 per cent in type 1, 10 per cent in type 3, and 50 per cent in type 4 ?
- (b) are they identical, or
- (c) are they progressively inferior, and, if so,
- (d) to what degree in other characteristics do they differ from non-fluorescent individuals in the respective types ?

“ It may be concluded alternatively that—

- (a) If all positive plants, irrespective of type, were identical, then the converse must be true, and all negative plants would be identical, irrespective of type. Consequently types 3, 4 and 5 would in the main be composed of two classes : first, the negative reacting class, a degenerate perennial ; and, second, a positive reacting class, a hybrid resulting from Italian crossed with true perennial or degenerate perennial ryegrass.

(b) If all positive plants in types 3, 4 and 5 exhibit a retrogressive degree of inferiority in proportion to their relative number, the same must be true of the negative reacting plants, which must become retrogressively inferior with decrease of numbers; from this, superficially positive and negative plants within a type must to all appearances be identical.

"In regard to conclusion (a), it is pointed out that the observations and conclusions of Levy and Davies do not suggest that types 3, 4, and 5 are degenerate perennials and hybrids in mixture in varying proportions, and, furthermore, one would not be inclined to regard this view as logically correct.

"The alternative conclusion (b) then appears to be the more acceptable; but although it is possible to advance theories as to the course of the factors for fluorescence and for persistency and to postulate the existence of controlling factors, it is considered advisable to wait until the material planted out has matured sufficiently to allow of examination and comparison, one class with another. Finally, the sowing of selected plants representative of each class is expected to yield many confirmatory data.

"An interpretation of the relationship between the positive and the negative material in each of the types is suggested graphically in Fig. 1. Although this will no doubt be subject to later modification, it serves to emphasize the fact that the percentage of positive seedlings in a sample does not indicate partial equality with true perennial, but, rather, the degree of perenniality."

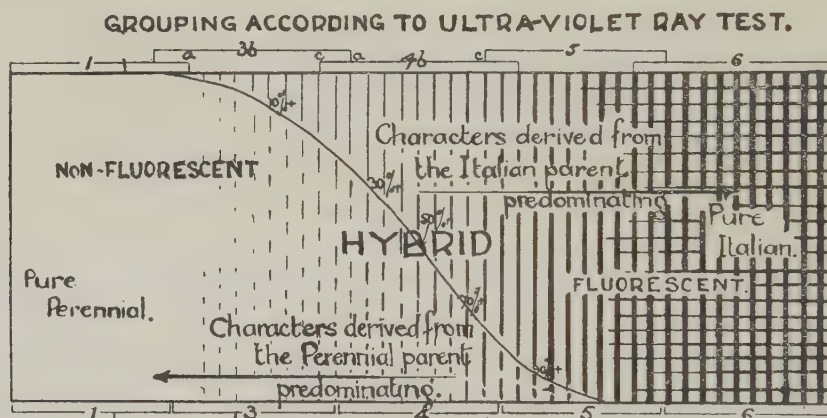


FIG. 1. THEORETICAL GROUPING.

GRAPHICAL REPRESENTATION OF RELATIONSHIP BETWEEN POSITIVE AND NEGATIVE MATERIAL IN EACH OF THE RYEGRASS TYPES.

Reviewing the position to date, while it has become necessary to amend to some degree the original conclusions drawn, the value of the ultra-violet light test in strain diagnosis can be reaffirmed.

The five plant types recognised by the Agrostologist are as follows :—

Type 1 : true perennial—N. Z. Certified and best Australian.

2 : " " —British indigenous.

3 : good false perennial—superior South Island (New Zealand) and best of British commercial.

4 : average false perennial—average South Island and poor British commercial.

5 : inferior false perennial—inferior South Island and poorest of British commercial.

The results of the ultra-violet examination of samples representative of the first three classes are presented in table 2. The test percentages of all lots represented therein are below 8 per cent, this being the maximum allowed for any line which reasonably may be regarded as perennial. There is strong evidence, however, that 5 per cent, as originally suggested, is a sufficiently generous allowance.

Table 2.—Analysis of samples showing not more than 8 per cent fluorescence.

Type.		No. of samples.	Percentage of samples showing :			Average percentage.
			0—3%	3.1 to 5%	5.1—8%	
1.	N.Z. Cert. Seed (Mother) ..	1350	76	20	4	3.1
	N.Z. Cert. Seed (Perm. Past.) ..	1225	67	27	7	3.8
2.	British indigenous	5	—	—	—	3.0
3.	Good false perennial	144	16	23	61	5.7

As a result of much wider application of the test it has been found necessary to modify somewhat the original conclusion that the ultra-violet light test could be used to diagnose from a seed sample the potential agronomic value of the line of seed represented. Later experiences have shown that where the depreciation in plant type is due to crossing of *L. perenne* and *L. multiflorum* or of *L. perenne* and existing hybrids, the results of such examination may be regarded as a measure of the degree of hybridization with the annual species of the inherited characteristics and in consequence an infallible indication of depreciation in plant type.

It is known, however, that in a minority of cases depreciation may be brought about by circumstances other than hybridization with an annual species, notably environmental conditions, the result being degenerate forms of perennial, which differ from the preceding class in that the perennial characteristics are retained while certain of the more important characters associated with perennial ryegrass of superior type are lost. The presence of a small percentage of fluorescent seedlings in samples from this group suggests that the original sowings were made with hybrid perennial ryegrass.

It will be seen that while the ultra-violet light examination may show the presence of only a small percentage of fluorescent seedlings for both groups, the test could not be taken to indicate agronomic equality. It would seem also that for both groups the indication of perennality or longevity could be accepted without question.

The 144 samples shown in table 2 are of New Zealand origin, the majority representing what may be termed "degenerate perennial"; of these 39 per cent show up to 5 per cent fluorescent seedlings. Approximately 30 per cent have been plot classified as 3a or "good type 3," a group intermediate between New Zealand No. 1 and average No. 3. These lots invariably gave a test of between 2 and 3 per cent fluorescence and are responsible for the lowering of the average for the group to 5.7 per cent. All these lots were from old pasture.

A small range of imported lines of which the plot classification is known have been examined, and the results indicate that a proportion of the low testing lots may prove relatively low in production.

Of 27 samples of Australian origin testing up to 5 per cent, 18 were classified as type 1, 4 as a doubtful 1 (probably 3a), and 5 as type 3. Five British indigenous lots tested at less than 5 per cent and were plot classified as type 2, together with one sample from Sweden showing 4.6 per cent fluorescence as type 3. The majority of English and European lots, however, test around 10 per cent and have been plot classified as type 3.

For types 3 and 5 it is considered unnecessary to present evidence additional to that shown in table 1. All such samples have invariably shown a high percentage.

As previously suggested, we may recognize two groups—

(a) the *major* group, wherein agronomic degeneration is due in greater part to hybridization, the degree of degeneration becoming proportional to the content of fluorescent individuals; in consequence a measure of the fluorescent content automatically provides a measure of the agronomic value;

(b) the *minor* group, wherein agronomic degeneration is due to the effect of unfavourable environmental influences on relatively pure perennial, and in consequence the fluorescent content may not be regarded as a measure of true agronomic value (e.g., low reacting lots of types 2 and 3a indicated above).

Fortunately, so far as New Zealand is concerned, areas representative of the second degenerate group are relatively few, so that the application of the results of ultra-violet light examination without previous plot trial can be made with a reasonably high degree of accuracy.

Fig. 2 (republished) indicates graphically the writer's conception of the genetical make-up of lots constituting group a. This suggests a certain simplicity of character inheritance, but it is impossible to demonstrate graphically the results of the many complex crosses which occur. The result considered as relative proportions of inherited perennial and annual characters is in most respects the same.

Agronomic classification of individual plants separated into reactive and non-reactive groups from lots of seed showing different percentages of fluorescence has thrown some light on the character and proportion of plants representative of the different recognised plant types.

Some three thousand seedlings, separated under the lamp, were planted out and classified after examination at several periods. The results confirmed earlier observations that positive reacting plants in low percentage lots would prove relatively superior, and conversely that non-reacting plants in high percentage lots would prove to be relatively inferior. Logically, therefore, in a lot showing 50 per cent fluorescence, the positive and negative individuals should exhibit an approximate equality, which, if a constant slight superiority of the negative plants over the positive plants for each lot is ignored, is actually the case.

In table 3 the proportion of plants representative of the various types is shown for seven lines of seed giving from 4 per cent to 83 per cent fluorescence. The relative inferiority of the positive plants will be observed, but the most obvious feature is the gradual depreciation of both negative and positive groups with increasing percentage of fluorescence. Type 6 is typical Italian ryegrass and is included in the table to complete the total of percentages.

Table 3.—Percentages of Plants—Positive or Negative for U.V. Light Reaction—Grouped according to Classification.

Plant type		1	2	3	4	5	6
Percentage fluorescence		%	%	%	%	%	%
4%	+	0.7	0.7	1.5	0.7	0.8	0
	—	68.7	8.3	18.6	0	0	0
Total :		69.4	9.0	20.1	0.7	0.8	0
8%	+	0	0	2.4	4.7	0.8	0
	—	31.8	6.3	47.6	6.3	0	0
Total :		31.8	6.3	50.0	11.0	0.8	0
12%	+	0	0	3.7	2.3	4.7	1.9
	—	0	5.6	67.3	16.8	0	0
Total :		0	5.6	71.0	19.1	4.7	1.9
20%	+	0	0	1.4	8.2	4.9	5.5
	—	0	0	38.3	36.9	4.8	0
Total :		0	0	39.7	45.1	9.7	5.5
30%	+	0	0	0	7.5	13.7	8.7
	—	0	0	27.5	35.0	7.5	0
Total :		0	0	27.5	42.5	21.2	8.7
50%	+	0	0	0	11.8	35.0	1.9
	—	0	0	8.0	27.0	16.3	0
Total :		0	0	8.0	38.8	51.3	1.9
83%	+	0	0	0	8.7	69.3	4.8
	—	0	0	5.8	9.2	2.2	0
Total :		0	0	5.8	17.9	71.5	4.8

These seven samples are, of course, selected from a number, by reason of the fact that they show so clearly what it is desired to demonstrate, but with a few exceptions representing degenerate perennial the composition of all lots is approximately as shown.

In the light of the evidence produced it is considered that the value of the ultra-violet test in indicating the degree of perenniality is proved, but that its use in diagnosing strain is limited, when the origin of the seed under examination is unknown. As previously stated, however, the proportion of degenerate perennial to hybrid perennial ryegrass is in New Zealand very small, so that as the nature of the perennial ryegrass produced in the various localities is known, the use of the lamp is not so limited as might at first be apparent.

At the New Zealand Seed Testing Station, several thousand samples have been examined on behalf of various Divisions of the Department and on behalf of merchants and growers. Officially, the test results are used in conjunction with plot trial data for the purposes of certification. Also samples of all lines of certified seed are examined, any lots showing fluorescence in excess of certain maxima being regarded with suspicion. Samples submitted unofficially are reported on as perennial or false perennial lots according to the test percentage.

In New Zealand, therefore, the quartz lamp is no longer an experimental novelty but an accepted factor in the technique of grassland research.

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